INNOVA® 310/320 SERIES ION LASER

OPERATOR'S MANUAL

THE COHERENT INNOVA 310/320 SERIES ION LASER

COHERENT®

Coherent Laser Group
5100 Patrick Henry Drive
Santa Clara, CA 95054

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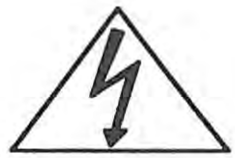

The lightning flash with arrowhead symbol is intended to alert the operator to the presence of dangerous voltage within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock to persons and to indicate possible risk of equipment damage.

The radiation symbol is intended to alert the operator to the danger of exposure to hazardous visible and invisible laser radiation.

The exclamation point is intended to alert the operator to dangers not arising directly from electrical or radiation hazards.

This symbol is also used to emphasize the presence of important operating and maintenance instructions in the documentation accompanying your laser system.

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PREFACE

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ABOUT THIS MANUAL

The INNOVA 310/320 Series Ion Laser Operator's Manual is divided into nine chapters and three appendices. This manual is the operating and maintenance guide to your new INNOVA 310/320 Series Ion Laser. As such, it contains information necessary for the effective utilization and upkeep of your laser.

Please read Chapter Two, Laser Safety, which deals with safety features and precautions specific to lasers. If this is your first ion laser, or you are new to lasers in general, read Chapter Seven, Theory of Operation. This chapter describes basic ion laser concepts and provides definitions of the key terms used throughout this manual.

PREFACE Introduction to the INNOVA 310/320 Series Ion Laser.

CHAPTER ONE **System Specifications,** describes model configurations and power specifications.

CHAPTER TWO **Laser Safety,** details special safety features incorporated into the INNOVA 310/320 Series Ion Laser under CDRH Guidelines. A detailed listing of all safety labels is also included.

CHAPTER THREE **Utility Requirements and System Installation,** details the electrical and water services necessary to operate the laser and provides comprehensive installation instructions.

CHAPTER FOUR **System Controls,** explains in detail the controls, their function and how to use them to operate the INNOVA 310/320 Series Ion Laser.

CHAPTER FIVE **Guide to Daily Operation,** contains daily start-up and shut-down procedures along with control sequences most likely to be used in everyday operation.

CHAPTER SIX **Optics and Alignment,** lists equipment required to carry out optical maintenance procedures and takes the user step-by-step through cleaning, removing and changing optics and alignment procedures.

CHAPTER SEVEN **Theory of Operation,** gives an in-depth description of all components, their uses and a definition of terms used in this manual.

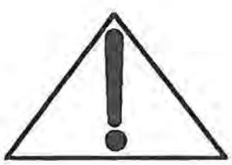
CHAPTER EIGHT — **Maintenance and Troubleshooting,** guides the user through maintenance procedures and lists the most common problems which may arise in everyday use, their probable cause and solution[1].

CHAPTER NINE — **External Computer Control of the INNOVA 310/320 Series Ion Laser,** contains information on how to operate your laser from a remote computer.

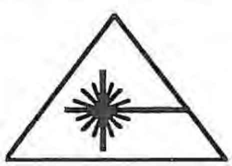
APPENDIX A — **Spare Parts and Accessories,** lists spare parts and accessories obtainable from Coherent.

APPENDIX B — **Supplementary Procedures,** describes how to change EPROM ICs and other procedures.

APPENDIX C — **Warranty,** details important warranty information about your INNOVA 310/320 Series Ion Laser system.



Read this manual carefully before operating the laser for the first time. Give special attention to the material in Chapter Two, Laser Safety, which describes the safety features built into the INNOVA 310/320 Series Ion Laser.



Caution — use of controls or adjustments or performance of procedures other than those specified in this manual may result in hazardous radiation exposure.

INTRODUCTION

As a member of Coherent's family of INNOVA Ion Lasers, the INNOVA 310/320 Series Ion Laser represents a line of reliable, high-performance lasers. With proper use and maintenance, the INNOVA 310/320 Series Ion Laser will deliver excellent performance over a long operating life.

Lasers and power supplies are inherently dangerous, but the risks can be minimized by a proper understanding of laser safety principles combined with a thorough knowledge of the instrument.

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[1] Applies to customer procedures only.

Figure 1. INNOVA 310/320 Series Ion Laser.

There are two argon laser system types in the INNOVA 310/320 Series Ion Laser family. The INNOVA 310 Series Ion Laser operates in a multiline configuration for visible wavelengths in the range 457.9 nm to 514.5 nm. The INNOVA 320 Series Laser operates in a multiline configuration for ultraviolet (UV) wavelengths in the range 333.6 nm to 363.8 nm. This manual describes the operation of both system types. Differences in operating procedures are few and are noted where appropriate.

PowerTrack™, a servo-controlled actively stabilized optical cavity, is a standard feature of the INNOVA 310/320 Series Ion Laser family. In addition, optional limited bandwidth operation in UV is available for the INNOVA 320 Series Laser.

LASER HEAD COMPONENT DESCRIPTION

All INNOVA 310/320 Series Ion Lasers have two major components, the laser head (where the laser light is produced) and the power supply.

LASER HEAD

The active medium in the laser head is a plasma of ionized gas contained in a low-pressure tube. A DC current, passed through the gas inside the tube, provides the energy which is converted to laser light through the process of stimulated emission. The plasma tube is positioned inside an optical cavity consisting of two dielectrically coated laser mirrors.

Coherent manufactures a selection of mirrors for various applications (Table 22).

AXIAL FIELD MAGNET

To control the current density and internal gas recirculation, a magnetic field is used to confine the plasma discharge. This confinement is accomplished by the use of an electromagnet which forms a sheath around the tube. The magnet sheath also provides a channel for cooling water to flow directly across the single-piece ceramic tube, carrying away the extreme heat produced in the plasma.

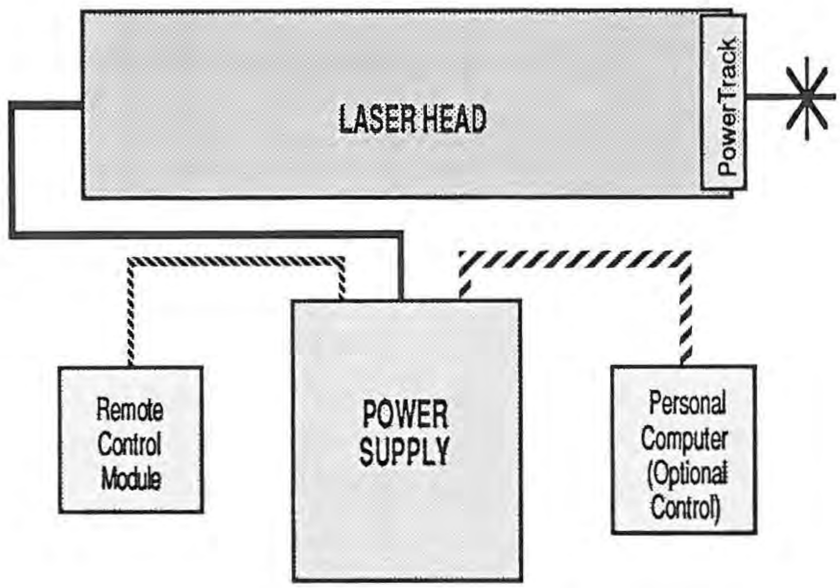

Figure 2. System Block Diagram.

RESONATOR STRUCTURE

All of the optical cavity components are attached to a rigid resonator structure consisting of three SuperInvar rods concentrically mounted inside steel tubing. The stainless tubing provides the mechanical rigidity necessary to keep the mirrors aligned while the SuperInvar rods provide maximum power stability and cavity length stabilization. The resonator structure and laser tube/magnet assembly are kinematically isolated from the laser head enclosure and from each other.

SEALED INTRACAVITY SPACE

The laser output mirror is protected by a beam enclosure that forms a sealed intracavity space, keeping the optic free of contamination without the use of a flowing gas purge. The enclosure incorporates a catalytic screen which

continuously controls the accumulation of ozone. The intracavity design uses hermetic seals and a bellows dust-shield arrangement. This design minimizes optical resonator detuning as the laser tube/magnet expands and contracts under varying heat loads.

SEALED MIRROR

The high reflector mirror is sealed onto the laser plasma tube. This design has two important advantages over the conventional Brewster window design. First, one source of power loss is eliminated from the optical cavity: the Brewster window itself. Second, no cleaning of this mirror surface is required.

The mirror is sealed onto a stainless steel bellows assembly which decouples the plasma tube from the optical resonator. Expansion or contraction of the plasma tube/magnet is not transferred to the mirror.

BEAM PICK-OFF AND PHOTOCELL

A beam pick-off inside the head directs a fraction of the output light onto a photocell. The current from this photocell is used by the system control circuitry as a measure of the laser output power.

IONPURE™ LASER TUBE

As laser tube components are subject to a variety of extreme stresses during operation, the IonPure plasma tube is fabricated from metal and ceramic parts which are brazed together in a high temperature furnace. The tube is assembled in an ultraclean facility to prevent contamination of components which might impair laser operation. Metal-ceramic construction provides a rugged structure which assures high reliability and a long operating life.

POWERTRACK™ ALIGNMENT SERVO

Optimum cavity alignment of INNOVA 310/320 Series Ion Lasers is automatically maintained during operation through servo control of the output mirror (front mirror). This feature, called PowerTrack, permits long-term stable operation without the need to periodically optimize the mirror alignment. PowerTrack also enables the laser to produce full power within one minute after the system starts, eliminating most of the warm-up time normally required with ion lasers.

INTRACAVITY APERTURE

All INNOVA 310/320 Series Ion Lasers include an intracavity beam shaping aperture which can be adjusted to produce an output beam whose radial intensity distribution is approximately a Gaussian TEM_{00}. Since this entails a loss of power that may not be desirable for certain applications, the aperture can be opened fully for maximum output power in a beam which is typically non-Gaussian (multimode).

Optical Controls

Two-speed tuning screws are used on the high reflector mirror plate (rear mirror) to provide smooth, precise alignment of the optical cavity. Optical controls for the high reflector mirror and the output mirror of the laser cavity are accessible when the laser head cover is in place, allowing the operator to make adjustments to the cavity alignment during operation.

Intracavity Shutter

The function of the intracavity shutter is to stop laser output by blocking the optical cavity space between the two mirrors without switching off the power supply or the flow of current through the plasma tube. The actuator is conveniently located externally, on top of the head cover.

Microprocessor Control

A CPU and two EEPROMs are used in the head to store calibration constants for the laser tube and laser head assembly. These constants are automatically downloaded to the main system CPU whenever the system is started.

Umbilical Configuration

The umbilical which connects the laser head and the power supply contains cooling water hoses as well as power and control cables. The umbilical can be quickly and easily configured to exit the rear or bottom of the laser head. Likewise, the umbilical connection on the rear of the power supply can be adjusted to exit horizontally or at 45°.

Power Supply Component Description

Microprocessor Controlled Power Supply

Electrical power to operate the tube is drawn from an incoming 3-phase power line and conditioned by the power supply. The power supply uses a 3-phase rectifier and LC filter to provide DC current for the tube and magnet. A linear passbank regulates this current in order to minimize the optical noise on the output beam.

The laser system is controlled by firmware located on the control board inside the power supply. This operating system is accessed by either the remote control module or the RS-232C interface.

A phone jack for the remote control module is located on the rear panel of the power supply. The head control port is also located on the rear of the power supply as is a DIP switch for configuration selection. There are three additional ports for customer supplied computer interfaces. These are: the standard RS-232C serial port, the standard analog/digital (0-to-5 VDC) port, and an optional IEEE-488 port.

Remote Control Module

System control is accessed through a compact remote control module which features pushbutton control of all operating parameters. The remote control module displays system status and operations on a 2-line, 16-character Liquid Crystal Display (LCD). All system functions are available to the operator through the remote control module either by dedicated buttons or by menu selection. A 4.9 m (16 ft.) cable (supplied with the unit) connects the remote control module to the power supply. An RS422 interface is used for the remote control module/power supply interface, allowing a maximum (shielded) cable length of 305 m (1000 ft.).

RS-232C Interface

An RS-232C connector is located on the rear panel of the power supply and is a standard 25-pin device. The RS-232 interface—a standard feature of the INNOVA 310/320 Series Ion Laser—provides the operator with the option of remote computer control of the laser system. Any computer equipped with an RS-232 interface card can be used.

IEEE-488 Interface

An IEEE-488 connector is located on the rear panel of the power supply. This connector is a standard 25-pin device designed to hook up with any computer system equipped with an IEEE-488 interface card.

0-to-5 VDC A/D Interface

An analog/digital (0-to-5 VDC) connector is located on the rear panel of the power supply. This analog/digital connector allows standard control of the laser system.

Light and Current Regulation Modes

In Light Regulation Mode, the operator can select a desired laser output power through the remote control module. Circuitry in the power supply compares desired power to actual power by monitoring the signal from the photocell in the laser head and continually adjusts the laser tube current to maintain a constant laser output level.

In Current Regulation Mode, the power supply maintains the laser tube current at a constant value. This value can be adjusted from the remote control module. Higher currents usually produce higher output powers. Refer to Chapter

One, System Specifications for minimum and maximum tube current.

Utilities

Power and Water Connections

The INNOVA 310/320 Series Ion Laser is powered by 3-phase AC service and requires a flow of water to cool the head and power supply. Specifications for these utilities are listed in Chapter Three, Utility Requirements and System Installation, Table 7.

Water and power are connected from the utility sources to the power supply and travel to and from the laser head through hoses and cables contained in the umbilical cord.

Closed-Loop Cooling System

If a closed-loop cooling system is used, be sure that it has sufficient capacity to dissipate the heat load of the INNOVA 310/320 Series Ion Laser as given in Table 7.

Laser Safety

Like any high-power laser, the INNOVA 310/320 Series Ion Laser poses severe safety hazards if operated carelessly or improperly. Safe operation of this laser requires operator familiarity with the hazards and recommendations presented in this manual, including the safety codes and materials referenced in Chapter Two, Laser Safety.

CDRH Classification

The INNOVA 310/320 Series Ion Laser complies with the U.S. Government Center for Devices and Radiological Health (CDRH) requirements for laser safety.

Under CDRH regulations, the INNOVA 310/320 Series Ion Laser is a CLASS IV laser product with a theoretical maximum operating power of 12 W of continuous near UV, visible and near IR radiation.

Before switching on your INNOVA 310/320 Series Ion Laser, it is imperative to familiarize yourself with the special safety features of this laser. Chapter Two of this manual contains vital information about safe operation.

Safety References

For further sources of laser safety information, refer to Chapter Two, Laser Safety.

Electrical Safety

The power supply cover is removable to facilitate certain maintenance and service procedures described elsewhere in this manual. Because high voltages are present in the power supply when the power is on, the power supply cover is interlocked and should not be opened during normal operation. Please read the appropriate sections of this manual carefully before attempting any maintenance of components housed in the power supply.

Operating the power supply with the interlocks defeated is a service procedure and may only be carried out by qualified personnel.

High voltages are also present in the laser head when the power is on. The head cover is interlocked and should not be opened during normal operation. Certain maintenance procedures, described elsewhere in this manual, require opening of the cover. Please read the appropriate sections of this manual carefully before attempting any maintenance of components housed in the laser head.

U.S. Export Control Laws Compliance

It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.

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CHAPTER ONE
SYSTEM SPECIFICATIONS

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This chapter contains system performance specifications for different models and configurations of the INNOVA 310/320 Series Ion Laser.

LASER MODELS

There are three argon models in the INNOVA 310/320 Series Ion Laser family.

There are two argon system types in the INNOVA 310/320 Series Ion Laser family. INNOVA 310 Series Ion Lasers are specified to a multiline visible open aperture power with a TEM_{01}* mode profile. INNOVA 320 Series Ion Lasers are specified to a multiline UV power with a TEM_{00} mode profile.

PERFORMANCE SPECIFICATIONS

OUTPUT POWERS

INNOVA 310/320 Series Ion Laser standard output power specifications are listed in Table 1 below.

OUTPUT POWER

INNOVA MODEL NUMBER	POWER	WAVELENGTH RANGE
318	8.0 W	457.9 - 514.5 nm
325	0.4 W	333.6 - 363.8 nm
326	0.5 W	333.6 - 363.8 nm

Table 1. Standard Power Specifications.

Output power for the INNOVA 318 is specified with a TEM_{01}*mode. Output powers for the INNOVA 325 and 326 are specified with a TEM_{00} mode.

An optional power specification for limited bandwidth UV output is available for the INNOVA 325 and 326. The guarantee for this specification includes an accessory output mirror and additional factory testing. You may purchase the output mirror without the testing and power guarantee. Part numbers for all INNOVA 310/320 output mirrors are given in Appendix A, Table 22.

UV OUTPUT POWER OPTION (TEM_{00})

INNOVA Model Number	Power	Wavelength Range
325	0.32 W	351.1 - 363.8 nm
326	0.40 W	351.1 - 363.8 nm

Table 2. Optional Power Specification, INNOVA 325/326.

Tube Currents

Table 3 lists the maximum and minimum plasma tube current by INNOVA 310/320 Series Ion Laser model number.

TUBE DISCHARGE CURRENT

Model	Maximum Tube Current	Minimum Tube Current High Field	Minimum Tube Current Low Field
318	55 A	(20 A)	10 A
325	45 A	20 A	(10 A)
326	45 A	20 A	(10 A)

Table 3. Maximum/Minimum Tube Current.

Output Beam Characteristics

Coherent specifies the optical properties, stability and noise of the INNOVA 310/320 Series Ion Laser output beam under standard operating conditions: multiline visible for the 310 Series and multiline UV for the 320 Series.

Power Stability

Power stability without PowerTrack is measured by recording the laser output power over a period of 30 minutes after a one-hour warm-up. The change in power recorded during this time is expressed as a percentage of the total power. Power stability with PowerTrack is measured over an eight hour period.

Optical Noise

Optical noise is measured by directing the laser output onto a photodiode and passing the resulting electrical signal through an analog filter with a 10 Hz-2 MHz bandpass. The filtered signal is read with an RMS voltmeter. This voltage represents beam noise expressed as a percentage of the average unfiltered photodiode output (DC level).

LONG-TERM POWER STABILITY	WITH POWERTRACK	WITHOUT [1] POWERTRACK
Light Regulation Mode 30 Min. Period 8 Hour Period	±0.5% [3] ±1.0% [2]	±0.5% [1] ——
Current Regulation Mode 30 Min. Period 8 Hour Period	±1.0% [3] ±1.0% [3]	±2.0% [1] ——

OPTICAL NOISE RMS, 10 Hz-2 MHz	MULTILINE VISIBLE	MULTILINE UV
Light Regulation Mode	0.2% [4]	0.5% [4]
Current Regulation Mode	0.2% [4]	0.5% [4]

[1] Maximum peak variation after one hour warm-up.
[2] Maximum peak variation after one minute warm-up.
[3] Maximum peak variation after fifteen minute warm-up.
[4] Measured with a 10 Hz-2 MHz photodiode driving a resistive load.

Table 4. Warm-up Power Stability and Noise Specifications.

The laser must be warmed up for at least one hour before checking beam noise and power stability without PowerTrack. For these specifications set the laser to produce the specified output power as listed in Table 1.

BEAM PARAMETERS

The INNOVA 310/320 Series Ion Laser optical cavity consists of a flat high reflector mirror and a curved output mirror. Since the radius of curvature of the output mirror is more than twice the length of the optical cavity, the optical configuration is that of a stable resonator. The intracavity beam has its smallest diameter at the high reflector mirror. Table 5 includes the calculated position of the virtual beam waist, located outside the cavity behind the high reflector mirror.

The beam diverges at the output mirror. Table 5 gives its full angle divergence.

CHARACTERISTIC	MEASUREMENT/ DESCRIPTION
BEAM DIAMETER @ $1/E^2$ POINTS	
318 MLVIS TEM_{01}*	2.2 mm at output mirror
325/326 TEM_{00}	1.6 mm at output mirror
VIRTUAL BEAM WAIST LOCATION	
318	1.42 m (measured from the output
325/326	1.41 m mirror toward the high reflector mirror)
VIRTUAL BEAM WAIST DIAMETER @ $1/E^2$ POINTS	
318	2.0 mm
325/326	1.4 mm
BEAM DIVERGENCE (FULL ANGLE)	
318	0.7 mrad
325/326	0.5 mrad
POLARIZATION RATIO	100:1 vertical: horizontal
CAVITY LENGTH	1.1 m

Table 5. Beam Characteristics.

For INNOVA 325/326 specification purposes, TEM_{00} operation is defined as the largest aperture setting which produces a smooth Gaussian intensity profile in the far field. Experience has shown that this definition is essentially equivalent to a visual examination of the beam by an experienced operator using a mode cup (a short radius mirror used to reflect and expand the beam). Users who have critical focusing requirements are cautioned that this definition allows for some small component of higher order mode to be present. This may result in a focused spot size larger than that calculated by equations that assume pure TEM_{00} mode. To obtain pure TEM_{00} mode, the aperture must normally be closed 1 to 2 stops from the setting determined from visual observation.

System Dimensions

The weight (crated and uncrated) and dimensions for INNOVA 310/320 Series Ion Lasers are listed in Table 6.

DIMENSIONS

	LASER HEAD	POWER SUPPLY	REMOTE CONTROL MODULE	UMBILICAL CORD
Length	122.5 cm (48.2 inches)	53.3 cm (21.0 inches)	11.3 cm (4.5 inches)	2.4 m (8.0 ft.)
Width	15.0 cm (5.9 inches)	54.3 cm (21.3 inches)	16.3 cm (6.44 inches)	—
Height	17.9 cm (7.0 inches)	19.3 cm (7.6 inches)	4.0 cm (1.6 inches)	—
Diameter	—	—	—	5.0 cm (2.0 inches)

WEIGHT

Weight (Crated)	81 kg (178 lb)	67 kg (148 lb)	—	—
Weight (Uncrated)	42 kg (92 lb)	39 kg (86 lb)	0.5 kg (1 lb)	—

Table 6. Shipping Dimensions and Weights.

Accessory Kit

All INNOVA 310/320 Series Ion Lasers include an accessory kit containing tools and supplies used in the normal maintenance of the laser.

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CHAPTER TWO
LASER SAFETY

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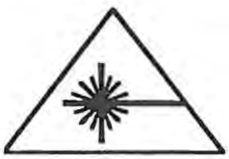
OPTICAL SAFETY

The INNOVA 310/320 Series Ion Laser is a precision laser and as such has undergone extensive testing to ensure that, with proper usage, it is a safe and reliable tool.

Laser light, because of its special properties, poses safety hazards not associated with light from classical sources. The safe use of lasers requires that all laser users and everyone working near a high-power laser be aware of the dangers involved.



Direct eye contact with the output beam from the INNOVA 310/320 Series Ion Laser will cause serious damage and may cause blindness.

All personnel in the same room as the laser or anyone who may be exposed to the laser beam should be informed that a laser is in operation. All personnel must wear laser safety glasses which protect against the wavelengths in use.

The greatest concern when using a high-power laser such as the INNOVA 310/320 Series Ion Laser is eye safety. In a laboratory setting, there are often many smaller beams present at various angles near the laser. These beams are formed by specular reflections of the main beam from polished surfaces such as lenses or beamsplitters. While weaker than the main beam, such beams may still be sufficiently intense to cause eye damage.

Laser beams are also powerful enough to burn skin, clothing or paint. They can ignite volatile substances such as alcohol, gasoline, ether and other solvents and can damage the light-sensitive elements in video cameras, photomultipliers and photodiodes.

The following recommendations are provided by Coherent to promote the safe use of the INNOVA 310/320 Series Ion Laser. Operators of the INNOVA 310/320 Series Ion Laser are advised to adhere to these recommendations and to employ sound laboratory practices at all times.

- Use protective eyewear whenever you operate the laser and guard against inadvertent exposure to skin or clothing. Select eyewear which is suitable for use with the wavelengths and radiation intensity that your laser produces. Refer to the *Laser Focus/Electro-Optics Buyer's Guide* or the *Lasers & Optronics Buying Guide* for suppliers of protective eyewear.
- Wavelengths shorter than 400 nm (UV) are invisible to the eye. When operating the laser in UV, take extra care to wear appropriate eyewear and to avoid inadvertent exposure to skin or clothing. In addition, assure that the work area has adequate ventilation to

minimize the risk from formation of toxic compounds due to interaction of the laser beam with the atmosphere.

- Do not remove protective covers from the laser head. During normal operation, internal reflections are confined within the laser head and pose no safety hazard. However, if you remove the head cover, intracavity beam enclosure, or rear mirror beam block, use extreme caution.
- Never look directly into the laser output port when the power is on.
- Do not stare at laser light reflected from any surface.
- Set up the laser and all experimental apparatus used with this laser below or above eye level. Provide enclosures for the laser beam.
- Use the laser in a room with access controlled by door interlocks. Post warning signs. When operating the laser, limit access to the area to individuals who are trained in laser safety.
- Do not operate the laser in a darkened environment.
- Do not use the laser in the presence of flammables, explosives, or volatile solvents such as alcohol, gasoline, or ether.

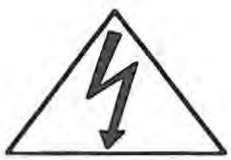
For additional information on laser safety, refer to the following publications:

- *Laser Safety Comes to Light* (videotape). ©Coherent, Inc., 1988.
- *American National Standard for the Safe Use of Lasers*, American National Standards Institute, 1980.
- *Performance Standards for Laser Products.* FDA., (FR-40) (148): 32252-32265. Department of Health, Education and Human Service. Bureau of Radiological Health, July 31, 1974.
- *Laser Safety Guide*, Laser Institute of America.(5th edition). Toledo, Ohio, 1982.
- D. Sliney and M. Wolbarsht: *Safety with Lasers and Other Optical Sources*, Plenum Publishing Co., New York, N.Y., 1980.

ELECTRICAL SAFETY

INNOVA 310/320 Series Ion Lasers are operated by high voltage DC power rectified directly from a 208 VAC, 3-phase power line. These voltages are sufficient to give a lethal shock. Every portion of the electrical system, including the printed circuit boards, should be considered to be at a dangerous voltage level. All the metal parts of the plasma tube, including the fill system, should be considered extremely dangerous. Avoid contact with anything in the laser head except the resonator assembly.

The laser head and power supply are equipped with safety interlocks on the access covers. Removal of these covers during operation will cause the laser to cease operation. Switch the laser off before removing any covers.



If the laser head cover is off while the laser is operating, assume that all metal parts of the plasma tube are at HIGH VOLTAGE.

CDRH COMPLIANCE

The following features are incorporated into the instrument to provide conformity to United States Government requirements 21 CFR subchapter, administered by the CDRH.

PROTECTIVE HOUSING

The laser head is enclosed in a protective housing that prevents human access to radiation in excess of the limits of Class I radiation as specified in the Federal Register, July 31, 1975, Part II, Section 1040.10 (f) (1) and table 1-A (except for the output beam, which is Class IV).

SAFETY INTERLOCKS

- The head cover is equipped with interlocks that prevent the laser from operating with the head cover removed (Figure 4).
- The power supply cover is equipped with an interlock that will prevent operation of the laser when the power supply cover is removed (Figure 4).

Means are provided to defeat these interlocks only for maintenance operations. Use extreme caution when the laser is operated with the interlocks defeated. There is danger of electrical shock and eye injury (CFR 1040.10(f)(2)).

EXTERNAL INTERLOCK CONNECTOR

Terminals on the rear of the power supply (the Analog Interface connector) are provided for an external interlock connection. These terminals must be connected for the laser to operate. An external interlock connector is shipped

in the maintenance kit for the laser system. The connector must be installed to defeat this interlock. Alternatively, this connector can be replaced with an external interlock circuit (Figure 4), (CFR 1040.10(f)(3)).

KEY CONTROL

The instrument cannot be switched on or operated until the key slot, located on front of the power supply, contains the key and is in the ON position (CFR 1040.10 (f)(4)).

LASER RADIATION EMISSION INDICATORS

The appropriately labelled lights on both the remote control module and the laser head illuminate approximately 30 seconds before laser emission can occur. White lights are used so that they will be seen regardless of the type of safety glasses which might be used (CFR 1040.10(f)(5)).

BEAM ATTENUATOR

A beam attenuator, or shutter, prevents contact with laser radiation without the need to switch off the laser (CFR 1040.10(f)(6)).

OPERATING CONTROLS

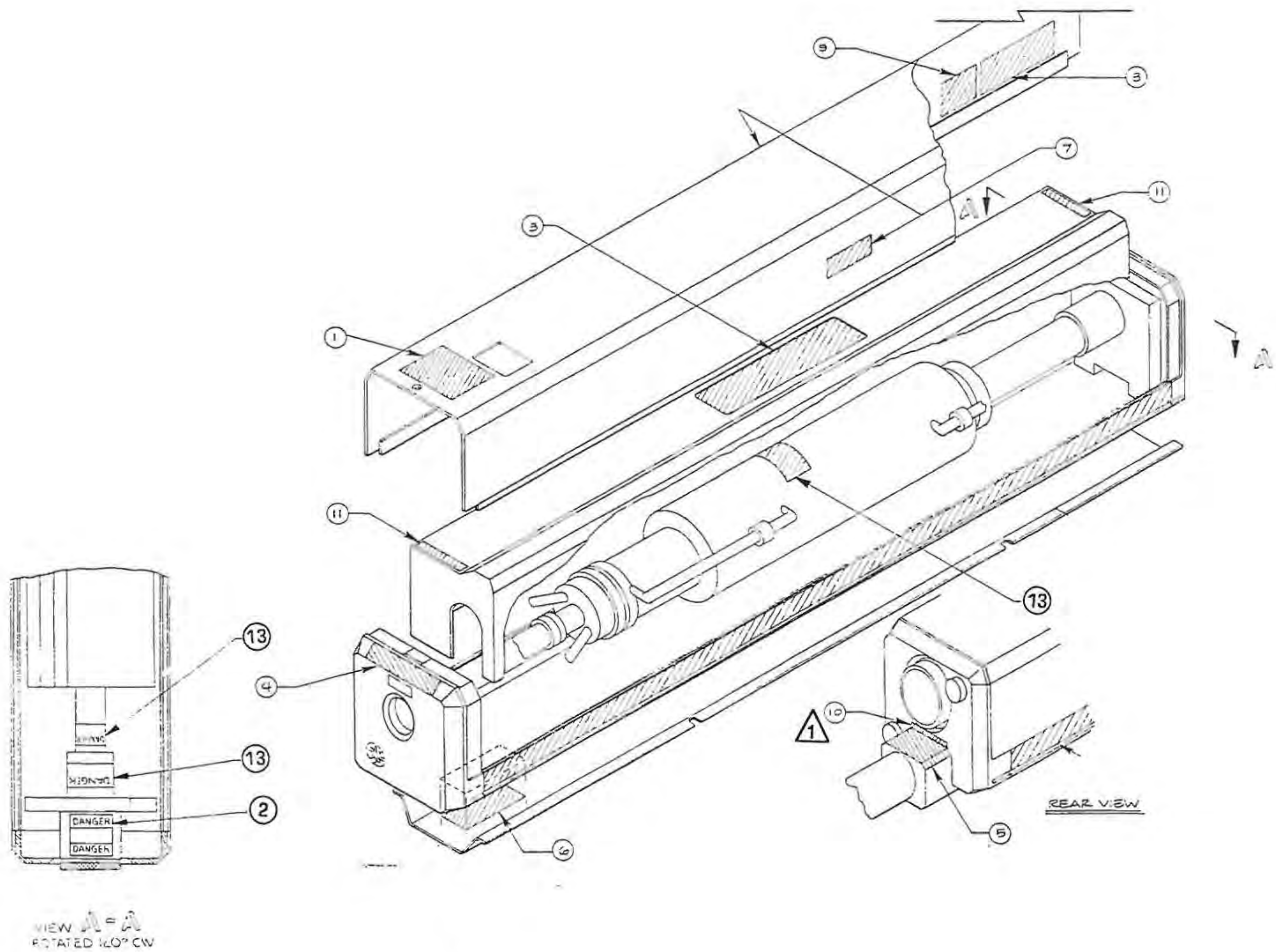
The INNOVA 310/320 Series Ion Laser controls are housed in a remote control module, which can be positioned so that the operator is not exposed to laser emission while manipulating the controls (CFR 1040.10(f)(7)).

HAZARDOUS RADIATION EXPOSURE

The INNOVA 310/320 Series Ion Laser Operator's Manual includes a caution that use of controls or adjustments or performance of procedures other than those specified in the manual may result in hazardous radiation exposure (CFR 1040.10(h)(iv)).

LOCATION OF CDRH COMPLIANCE LABELS

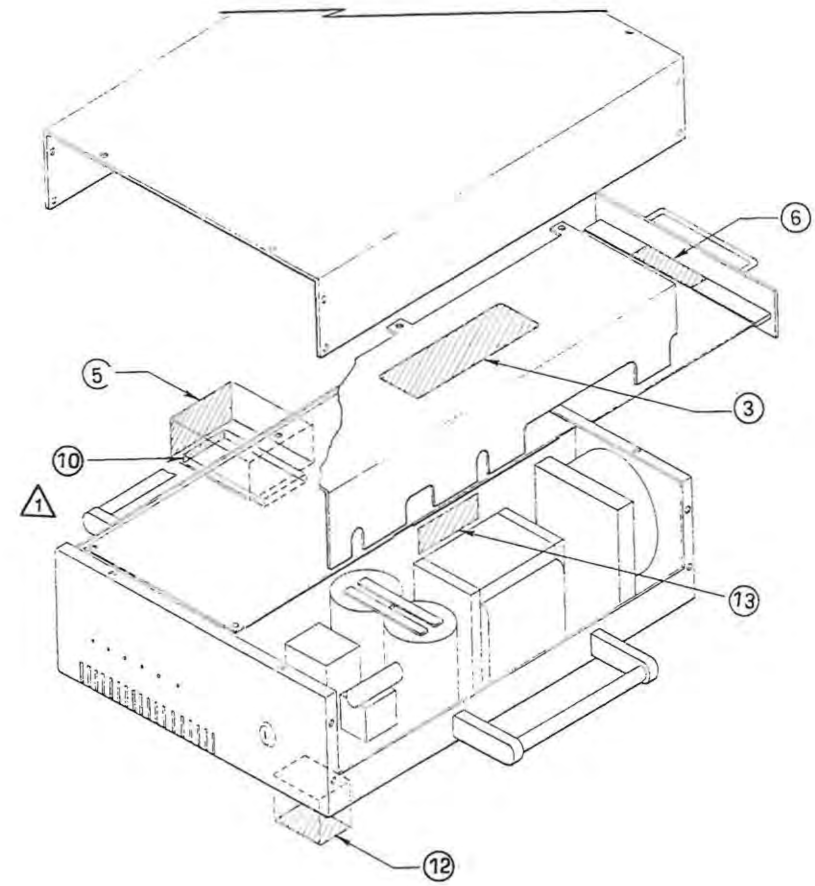
Refer to Figures 3a and 3b for a description and location of all CDRH-required labels. These include warning labels which indicate removable or displaceable protective housings, apertures through which laser radiation is emitted and labels of certification and identification (CFR 1040.10(g)), CFR 1040.10(g), CFR 1040.10(g)(5) and CFR 1010.2)).



Notes:

⚠1 This label affixed to French shipments only.

Figure 3a. Location of Safety Labels, Laser Head.



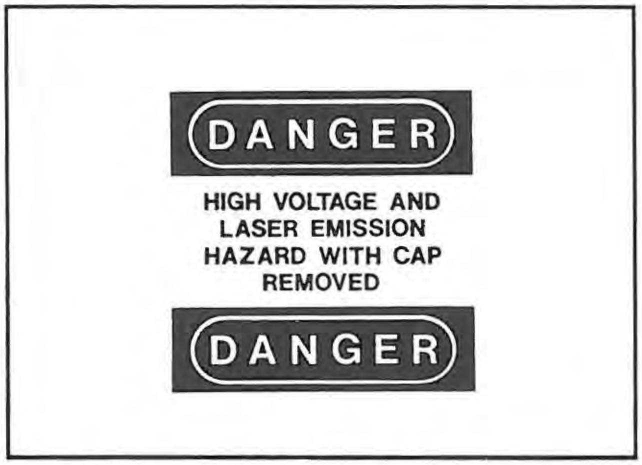
Note:

⚠1 This label affixed to French shipments only.

Figure 3b. Location of Safety Labels, Power Supply.

1. Danger, Radiation (argon).

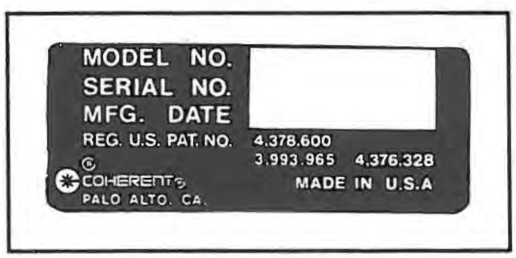
Key to Figures 3a and 3b.



2. Danger, High Voltage/Laser Emission.

3. Warning, Dangerous Voltage.

4. Avoid Exposure.



5. Serial Number (patent).

Key to Figures 3a and 3b.

CAUTION

THIS CIRCUITRY IS REFERENCED
TO B- (-150VDC) DO NOT
USE GROUNDED TEST EQUIPMENT

6: Caution, Circuitry Reference to B-.

DANGER

VISIBLE AND INVISIBLE LASER
RADIATION WHEN OPEN AND
INTERLOCK DEFEATED. AVOID EYE OR
SKIN EXPOSURE TO DIRECT OR
SCATTERED RADIATION.

7. Interlock Defeat.

TUBE INSTALLATION RECORD — HEAD NO. ______

TUBE S/N	TIMER READING	DATE	SIGNATURE

8. Tube Installation.

COHERENT®
3210 PORTER DR., PALO ALTO, CA. 94304

THIS INSTRUMENT CONFORMS TO
COHERENT'S STANDARDS OF SAFETY
WORKMANSHIP AND PERFORMANCE.
TESTED BY:____________ __/__/__
Q.C. INSPECTOR:____________

9. Coherent Standards.

Fabrique aux E.U.A.N.

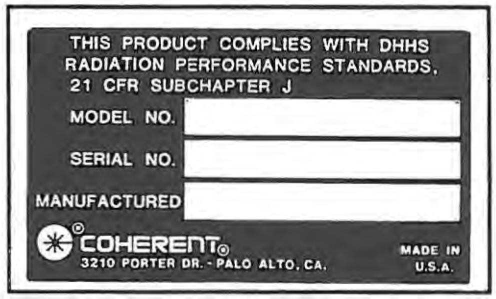
10. French (option).

DANGER

VISIBLE AND INVISIBLE RADIATION WHEN
OPEN AND INTERLOCK DEFEATED. AVOID EYE OR SKIN
EXPOSURE TO DIRECT OR SCATTERED RADIATION.

11. Interlock Defeat.

Key to Figures 3a and 3b.



12. Serial Number (compliance).

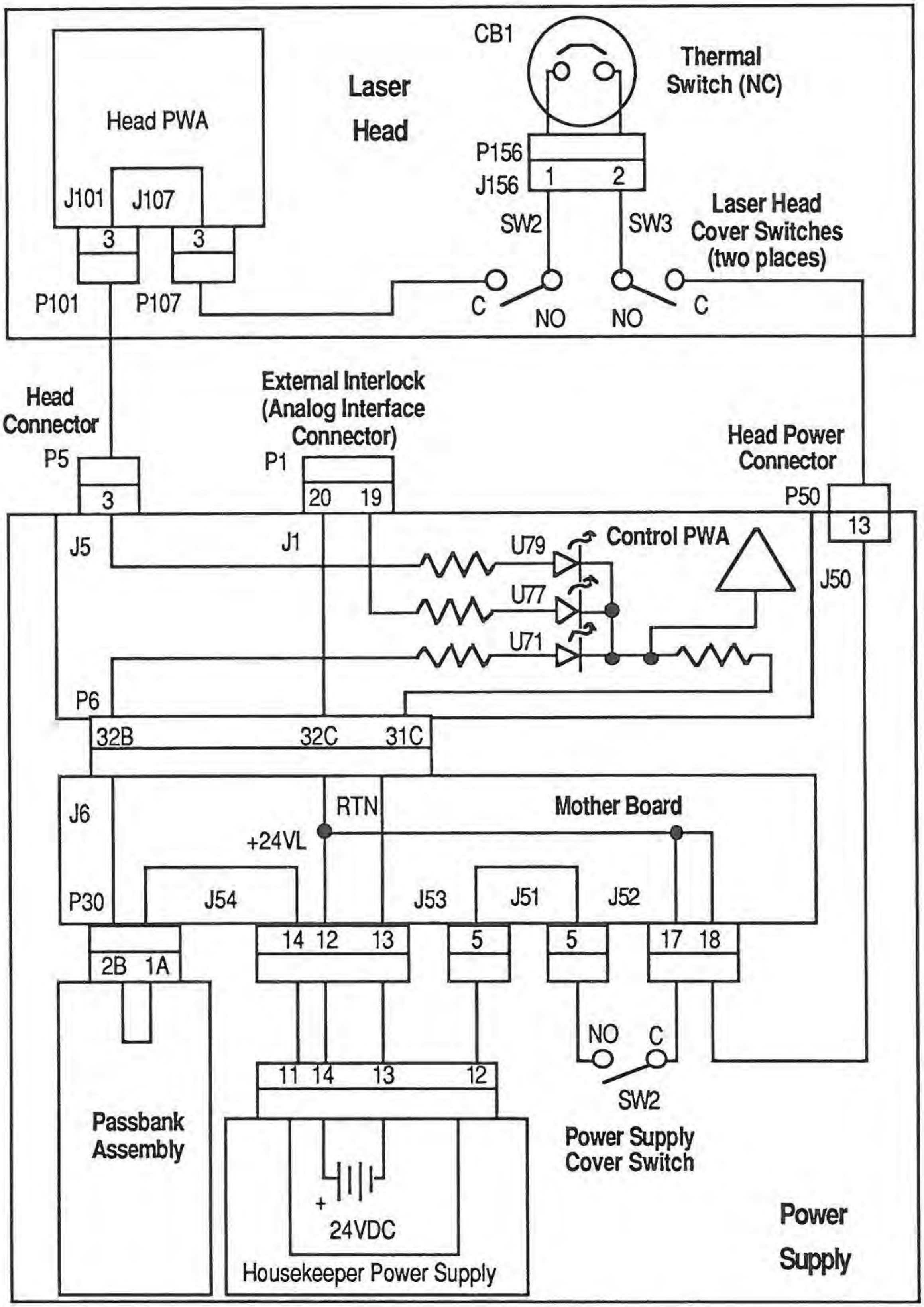
13. Danger High Voltage.

Key to Figures 3a and 3b.

USE OF THE INNOVA 310/320 FOR LIGHT SHOWS

The U.S. Food and Drug Administration has special requirements for lasers intended to be used for light show or demonstration purposes within the United States.

As a Class IV laser system, the INNOVA 310/320 Series Ion Laser complies with all safety and performance standards. However, additional certification is required to assure that suitable means of radiation safety and protection will be provided by the light show producer. Please contact the FDA Office of Compliance at 301-427-1172 for further information about laser certification for light shows or demonstrations.



Note: All three opto-couplers, U71, U77, U79 must have current flow to operate the laser.

Figure 4. INNOVA 310/320 Series Ion Laser Interlock Circuit, Simplified Schematic.

OPERATOR'S MANUAL

CHAPTER THREE
UTILITY REQUIREMENTS AND SYSTEM INSTALLATION

COHERENT®

UTILITY REQUIREMENTS

The INNOVA 310/320 Series Ion Laser requires electrical power for the power supply, as well as a supply of water to cool both the laser head and the power supply.

Please have your plant engineer read this section to ensure the optimal working conditions for your new laser.

POWER REQUIREMENTS

208 VAC ± 10 %
3-phase with ground, no neutral
Recommended Capacity: 60 A per phase, 50 or 60 Hz

MAXIMUM CURRENT CONSUMED (TYPICAL)

318	55 A per phase at 208 VAC
325	50 A per phase at 208 VAC
326	50 A per phase at 208 VAC

COOLING WATER REQUIREMENTS

Flow rate, minimum	8.5 liters (2.2 U.S. gallons) per minute
Recommended maximum flow rate	11.6 liters (3.0 U.S. gallons) per minute
Static pressure [1]	Max: 620 kPa (90 psi)
Pressure Delta [2] range	152-276 kPa (22-40 psi)
Inlet temperature	10-35°C (50-95°F)
Temperature stability	±1°C (1.8°F)
Resistivity	5.0 KΩ-cm - 2.0 MΩ-cm
pH	6-8
Hardness	<100 mg/l (5.9 grains/gal) or 100 parts/million of calcium
Particulate size	<200 microns in diameter. [3]

TOTAL HEAT LOAD PRODUCED BY INNOVA 310/320 LASERS

318	23 kW @ 230 VAC 21 kW @ 208 VAC
325/326	20 kW @ 230 VAC 18 kW @ 208 VAC

Note: These figures include the two 7.6 m (25 ft.) lengths of 16 mm (5/8 inch) I.D. hose which are supplied with each laser.

These figures do not include a 60 micron water filter. A new 60 micron water filter introduces a 5 kPa (0.75 psi) pressure delta at 22.7 liters (6 gallons) per minute or a 2 kPa (0.30 psi) pressure delta at 8.3 liters (2.2 gallons) per minute.

[1] Static pressure is the inlet pressure measured under conditions of zero flow.

[2] Pressure Delta is the pressure differential between inlet and drain.

[3] Coherent supplies a 60 micron water filter with the system.

Table 7. Utility Requirements

ELECTRICAL SERVICE

The AC electrical service for the INNOVA 310/320 Series Ion Laser power supply must meet the specifications listed in Table 7.

Attached to the power supply is a ten-foot power cable without a connector attached to the free end. The cable is Type SO-4/4, four wires, #4 AWG. You must provide the hardware necessary to connect this cable to your electrical service. Consult applicable electrical codes for your area to select this hardware. The electrical service may be either WYE or Delta connected, with the fourth wire connected to building ground. WYE is recommended as it is more tolerant to line voltage imbalances from each phase to ground.

The service should have a main power disconnect switch located in the same room as the laser.

COOLING WATER

The INNOVA 310/320 Series Ion Laser requires a flow of cooling water for the laser head as well as for electrical components inside the power supply. Because properties of the cooling water are of critical importance to the performance of the laser, make certain that the cooling water in your work area conforms to the specifications listed in Table 7 at all times.

Check local and state regulations which may control use of city water for cooling. For instance, some regulatory codes will not allow the discharge of cooling water into the sewer system.

The minimum water pressure drop through the laser is 152 kPa (22 psi) at a flow rate of 8.5 liters (2.2 U.S. gallons) per minute.

The cooling water temperature must not fall below the ambient dew point. If this does occur, condensation will form inside the power supply and may cause catastrophic damage. In some situations it may be necessary to provide humidity control for the laser environment.

CLOSED-LOOP COOLING SYSTEM

If your cooling water does not meet specifications, you may wish to install a closed-loop heat exchanger to obtain optimum performance from your laser. Should you decide to

use a closed-loop cooling system[1], ensure that it has sufficient capacity to handle the heat loads listed in Table 7.

If your application demands critical beam pointing or power stability, the use of pressure and temperature regulators on the cooling water system may also be advantageous.

Ambient Temperature

The room in which your laser is located should be maintained at a temperature of 10-40°C (50-104°F).

Site Preparation

Planning the Workspace

To assist you in planning sufficient workspace for the INNOVA 310/320, dimensions of the laser system are given in Table 6, Chapter One. Enough space should be left around the laser head so that the components inside can be reached easily for alignment and maintenance.

Umbilical Cord

The laser head and power supply are connected through an eight-foot umbilical cord. This cord must not be crimped or bent sharply. To avoid crimping, use a bend radius of at least 30 cm (12 in.) for the umbilical cord.

Work Surface

The INNOVA 310/320 Series Ion Laser is a precision instrument whose performance depends on its environment. Vibrations can be transmitted to the laser head from the surface on which it rests, causing beam pointing instability and beam amplitude fluctuations. To minimize vibrations, the laser head should be placed on a stabilized optical table and isolated from mechanical contact with other equipment.

Unpacking the System

The INNOVA 310/320 Series Ion Laser is shipped in two crates: one contains the power supply, the other the laser head. Accessories, including the remote control module, are packed in separate boxes. A packing list, which details all

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[1] Further information about the use of closed-loop cooling systems, and the Coherent manufactured LaserPure™ Heat Exchangers, is available from Coherent Technical Support at 800-367-7890.

the ordered items, is included in the shipment. Please check items received against this packing list.

Please advise your receiving department to perform the damage inspection procedure prior to signing the bill of lading.

DAMAGE INSPECTION

Carefully inspect each crate and note any damage. All INNOVA 310/320 Series Ion Laser crates are shipped with rough handling indicators affixed to their front and back. Examine these indicators upon receipt. If the indicator bar is red, the crate has received handling which may have damaged the contents. Indicate any such signs on the bill of lading.

Report any damage immediately to the shipping carrier and to the Coherent Order Administration Department, 800-438-6323.

UNCRATING

To minimize the risk of functional or cosmetic damage to your laser system, uncrate the laser head and power supply at the installation site.

To prevent serious damage, care must be taken when cutting wrapping materials from any of the items contained in the crates, particularly around the laser head and the umbilical cord. This warning also applies to opening accessory boxes and the unpacking of their contents.

Keep all shipping containers. If you file a claim for shipping damage, the containers may be needed to support the claim. In addition, if you return the laser system to Coherent for service, these containers will best protect your system in shipment. See below for storage information.

LASER HEAD

Loosen the retaining clips and remove the cover of the box containing the laser head.

1. Remove the accessory boxes from the head crate.
2. Carefully remove the umbilical cord from the crate.
3. Remove the laser head from the crate and set it on the work bench (two people required).

4 Remove the plastic wrapping from the umbilical cord at the rear end of the laser head.

5 Remove the water and power connectors from their plastic bags and protective foam padding.

Leave the ESD (ElectroStatic Discharge) protective foam padding on the red power connector until ready to connect it to the power supply.

POWER SUPPLY

Loosen the retaining clips and remove the cover of the box containing the power supply.

1 Remove the foam padding from the top of the power supply.

2 Lift the power supply out of the crate and carefully set it on a flat, stable surface (two people required).

3 Remove the plastic bag affixed to the top of the power supply.

4 Take the key out of the accessory box and insert it into the lock on the front of the power supply.

SHIPPING CRATES

The shipping crates are specially designed to protect your laser system during transit. It is important, therefore, that these crates be undamaged and stored for future use. For storage information, the dimensions and approximate weight of the boxes/crates are listed in Table 8.

	POWER SUPPLY	LASER HEAD	ACCESSORIES
Length	91.0 cm (36.0 in)	201.0 cm (79.0 in)	71.00 cm (28.00 in)
Width	74.0 cm (29.0 in)	53.0 cm (21.0 in)	39.30 cm (15.50 in)
Height	48.0 cm (19.0 in)	48.0 cm (19.0 in)	30.40 cm (12.00 in)
Weight	28.0 kg (62.0 lbs)	39.0 kg (86.0 lbs)	1.8 kg (4.0 lb)

Table 8. Dimensions and Weights of Empty Shipping Crates.

INSTALLATION

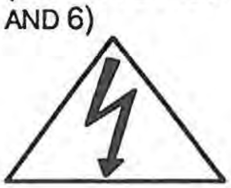
The INNOVA 310/320 Series Ion Laser is designed to be installed by the user. Installation should be carried out by a qualified technician. Follow the procedures detailed in this chapter to ensure proper installation of your system.

Should you prefer, Coherent Service will install your laser and provide basic training to the operator for an additional charge. After completing the unpacking procedures, call Coherent Customer Service at one of the phone numbers listed at the front of this manual to schedule installation.

PREPARING THE LASER HEAD FOR INSTALLATION

1. Take off the top cover of the laser head by removing the two cover screws.
2. Remove the plastic safety cover inside the laser head by removing the screws on top of the plastic cover.
3. Inspect the laser head for damage.

POWER SUPPLY INSTALLATION
(REFER TO FIGURES 5 AND 6)

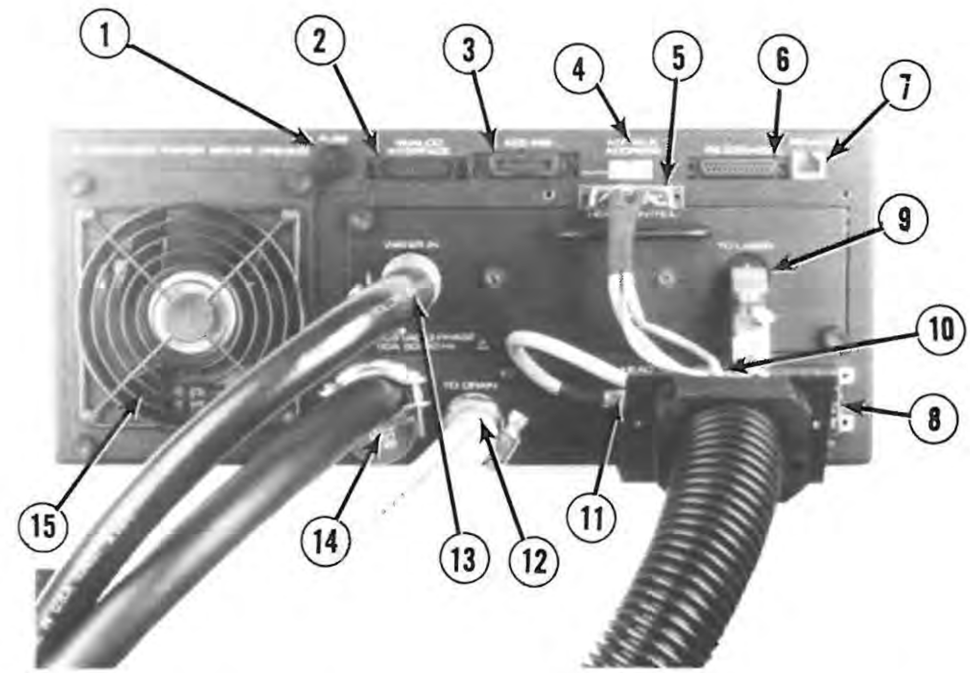


Connection of the power supply utilities should be carried out only by a qualified technician. Any adjustments or repairs to the power supply carried out by anyone other than a qualified technician, or an operator working under direct consultation with a Coherent qualified technician, will void the warranty agreement.

If you have any questions regarding utility connections, or any other installation procedure, contact Coherent Technical Support.

POWER CONNECTION

Attach a properly rated connector (not supplied by Coherent) to the four-wire cable. The green wire is ground. The remaining three wires go to the three phases. There is no required phase rotation order. There is no neutral connection.



Key:
1 Fuse (3 A, 250 V, slow blow)
2 Analog Interface (remote computer interface)
3 IEEE 488 (remote computer interface)
4 My Talk Address (dip switches)
5 Head Control (DB25)
6 RS-232/422 (DB25 remote computer interface)
7 Remote (remote control module)
8 Head Power
9 To Laser (water)
10 From Laser (water)
11 Head Ground
12 To Drain (water)
13 Water In (water from source)
14 208 VAC, 3-phase, 60 A, 50/60 Hz (power from source)
15 Cooling Fan

Figure 5. INNOVA 310/320 Series Ion Laser, Power Supply, Rear Panel

All connectors on the rear of the power supply are clearly labelled. Refer to Figure 5 for labelling of rear panel items. Refer to Figure 6 for umbilical, water, external interlock, and remote control module connections.

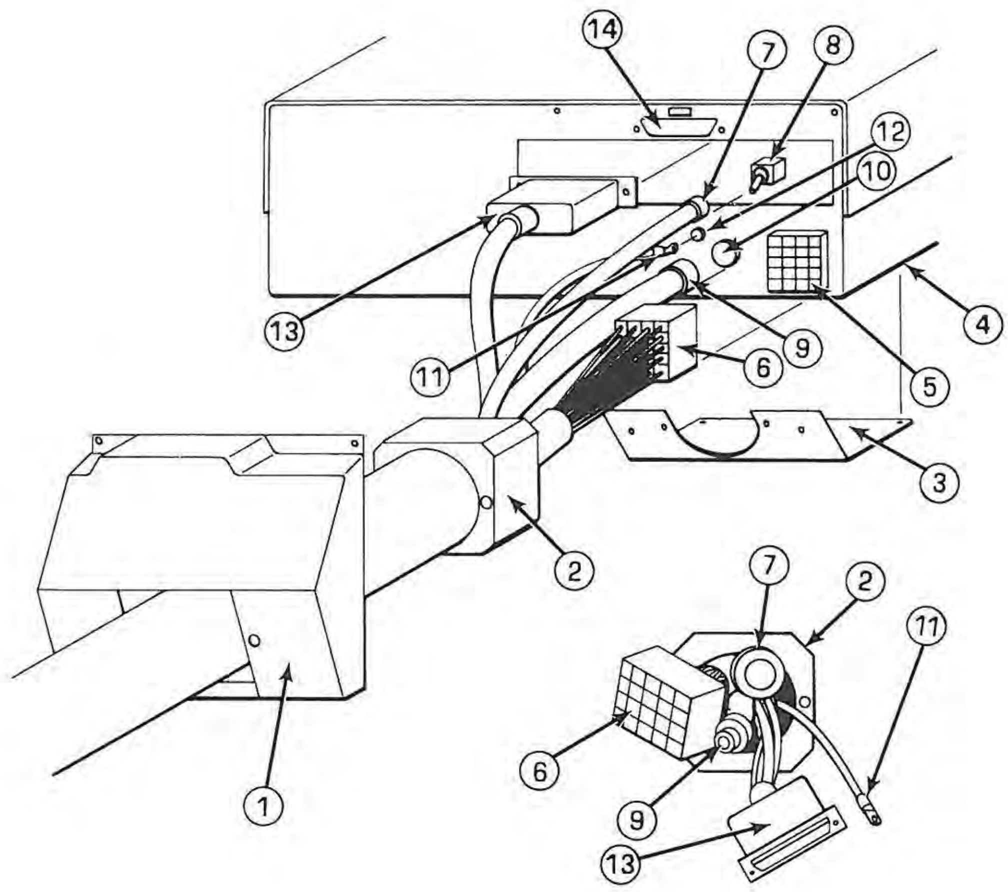
UMBILICAL CONNECTIONS (REFER TO FIGURE 6)

Ensure the umbilical connections cover **(1)** and the umbilical holder **(2)** are in place on the umbilical assembly. Make the umbilical connections as follows:

1. Move the power supply so that the rear panel extends approximately two to three inches beyond the table edge.
2. Take off the umbilical support bracket **(3)** by removing the two hex screws (using a 1/8 in. Allen wrench) that secure it to the bottom of the power supply **(4)**.

3 Remove the four Phillips head mounting screws for the red 20-pin laser head power receptacle (**5**).

4 The two water hoses, connected together at the end of the umbilical for shipment, should now be disconnected. Refer to Figure 6, Umbilical Assembly End View. Make certain that the water hoses and connectors on the umbilical exit the umbilical as shown in the illustration.



Key:

1 Umbilical Connections Cover
2 Umbilical Holder
3 Umbilical Support Bracket
4 Power Supply
5 Laser Head Power Receptacle
6 Laser Head Power Connector
7 Female Quick-Disconnect (red band)
8 To Laser Water Connection
9 Male Quick-Disconnect
10 From Laser Water Connection
11 Head Ground Lug
12 Head Ground Stud
13 Head Control DB25 Plug
14 Head Control Connector

Figure 6. Umbilical Connections.

5 The red 20-pin laser head power connector (**6**) is held together by a metal clamp. This clamp also

assists in the installation of the connector. Insert the 20-pin laser head power connector (**6**) on the umbilical into the receptacle (**5**) on the rear of the power supply labelled HEAD POWER. Check that all pins are aligned and engaged. Rock and push the connector until it is completely seated in the receptacle. Secure the connector with the four Phillips head screws.

6 Attach the hose with the female quick-disconnect (**7**) (red band) to the connector on the rear of the power supply labelled TO LASER (**8**).

7 Attach the hose with the male quick-disconnect (**9**) to the connector on the rear of the power supply labelled FROM LASER (**10**).

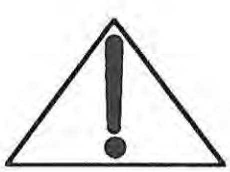
8 Remove the nut and washer from the stud (**12**) labelled HEAD GROUND. Place the lug (**11**) on the green head ground wire onto the stud. Replace the washer and nut. Tighten the nut firmly using a 7/16 inch nut driver.

9 Replace the umbilical support bracket (**3**). Seat all the cables protruding from the umbilical cable into the cut out in the umbilical support bracket. Be careful not to pinch or crimp any of the wires. The wires to the red 20-pin laser head power connector (**6**) and the wires to the DB25 plug (**13**) are protected by plastic sleeves. Make sure that the sleeves protrude far enough to protect the wires from the edges of the support bracket (**3**).

10 Rotate the umbilical holder (**2**) so that the umbilical will exit the rear of the power supply horizontally or at 45°.

11 Secure the umbilical holder (**2**) to the umbilical support bracket (**3**) with the long screws provided using a 9/64 in. straight ball driver.

12 Attach the DB25 plug (**13**) to the connector on the rear of the power supply labelled HEAD CONTROL (**14**) Secure the mounting screws on the plug with a screwdriver.



Ensure the DB25 umbilical connector is plugged into the connector labelled HEAD CONTROL (located immediately below the MY TALK ADDRESS dip switch panel). *Do not* plug the DB25 into the RS-232/422 connector (located to the right of the MY TALK ADDRESS dip switch panel).

All connections must be tight due to the large electrical currents involved. Verify that all connectors are fully mated and that no wires have damaged insulation or are crimped or bent sharply.

WATER CONNECTIONS (REFER TO FIGURE 6)

1 Be sure there are hose washers in the water supply and drain connectors.

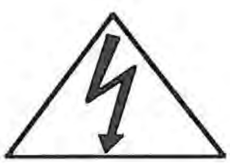
2 Attach the hose with the female connector to the connector on the rear of the power supply labelled TO DRAIN. Direct the other end to the drain outlet.

3 Attach the water filter provided by Coherent to the cooling water source.

4 Attach the second water hose with the male connector to the water filter and to the coupler on the rear of the power supply labelled WATER IN.

5 Open the drain valve and then slowly open the water inlet valve. Look for leaks in the fittings, head and power supply.

6 If there are no water leaks, replace the power supply cover, the laser head plastic safety cover and the laser head cover.



Only the magnet water jacket is connected to ground. No part of the tube or reservoir should touch the case.

7 Use a 1/8 in. Allen wrench to remove the two screws from the power supply and the two screws from the umbilical support bracket which will hold the umbilical connections cover (**1**) in place.

8 Slide the umbilical connections cover (**1**) over the umbilical holder and bracket so that the screw holes on either side of the center opening are aligned with those on either side of the umbilical holder. Secure this assembly using two of the shorter screws provided.

9 Secure the top of the umbilical connections cover (**1**) to the power supply using the four screws removed above.

10. Connect the power supply power cord to the facility power.

External Interlock Connection

Connect the external interlock connector which is shipped in the maintenance kit or an appropriate external interlock circuit (below for details) to the socket labelled ANALOG INTERFACE on the rear panel of the power supply (Figure 5, Item 2).

The external interlock connector provides a jumper between pins 19 and 20 of the ANALOG INTERFACE socket. These terminals must be connected for the laser to operate. The connector may be replaced with an external interlock circuit.

The External Interlock circuit may be wired to a door switch to shut off the laser when a person enters a designated restricted area.

The external interlock has an open circuit voltage of 20-28 VDC and a short circuit current of $\leq$ 6.0 mA. Under no circumstances should an external voltage or current source be connected to this circuit. If the external resistance connected between pins 19 and 20 is less than 10 Ω, the laser is functional and will operate from remote module or computer control. If the resistance is greater than 100,000 Ω, the laser is disabled and will not operate. To assure proper functioning of your laser system, design your external interlock circuit to have a resistance less than 10 Ω when closed and a resistance greater than 100,000 Ω when open. External interlock circuitry should be isolated from all other electrical circuits or grounds.

If the external interlock is open (connector not installed or restricted area door open), the laser will not operate. The remote control module display will read: **External Interlock.**

Remote Control Module Connection

The remote control module cable has a phone jack connector which plugs into the receptacle labeled REMOTE on the rear panel of the power supply (Figure 5, Item 7). Plug in the jack and make sure the connection is secure.

Before turning the laser system on, please read Chapter 4, System Controls, and Chapter 5, Guide to Daily Operation. Follow the proper start up procedures.

Test and Maintenance Equipment

In addition to the maintenance kit supplied by Coherent with your INNOVA 310/320 Series Ion Laser, it is recommended that you acquire the items listed below for the general upkeep of your laser.

Output Power Measurements

The INNOVA 310/320 Series Ion Laser has a built-in power monitor which reports the laser output power through the LCD on the remote control module. The power monitor is factory calibrated and requires no further adjustment. The correct wavelength must be selected on the remote control module for proper calibration.

INNOVA 310/320 Model	Coherent Power Meter	Power Meter Capacity
318	LabMaster LM-45	45 W
	Model 203	
325/326	LabMaster LM-10	10 W
	Model 210	10 W with 210-01 Range Extender

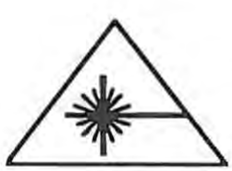
Table 9. Recommended Power Meters.

If you wish to have an accessory power meter available, it should be rated for the full power output of the laser. Coherent Power Meters are listed in Table 9.

Output Mode Measurements

When your system is installed, you may verify that the output mode meets specifications.

If an application demands routine examination of the laser mode, several options are available which differ widely in cost and accuracy of measurement. The simplest and most inexpensive device is a modecup, a short focal-length lens or mirror which can be used to project the beam onto a wall or screen for visual inspection.



Use extreme caution when projecting an expanded laser beam with a mode cup. The expanded beam is sufficiently intense to cause severe eye damage.

For more precise measurements, a beam scanner, spectrum analyzer or M^2 meter such as the Coherent ModeMaster can be used. Refer to Chapter Five or contact Coherent Technical Support at 800-367-7890 for more information on how to use this equipment with your INNOVA 310/320 Series Ion Laser.

Operator's Manual

Chapter Four
System Controls

Coherent

This chapter describes the controls and indicators on an INNOVA 310/320 Series Ion Laser system. The chapter is divided into three sections:

Power Supply Controls lists and details controls on the power supply and their functions.

Remote Control Module explains how the remote control module is utilized to control laser operation through the CPU.

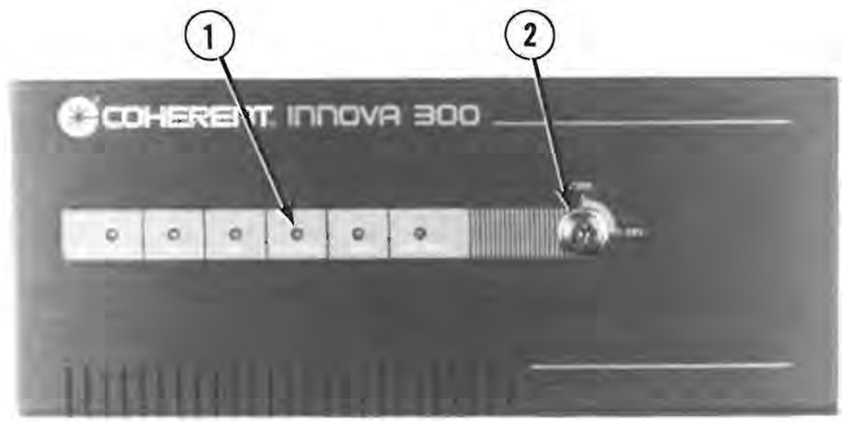
Laser Head Controls describes the controls situated on the laser head and how these are used to optimize laser operation.

POWER SUPPLY CONTROLS

There are few controls on the power supply. The master ON/OFF keyswitch and six indicator LEDs are located on the front panel. A set of dip switches, labelled MY TALK ADDRESS, is situated on the rear panel.

SYSTEM KEYSWITCH

The system keyswitch is located on the front panel of the power supply. In the OFF position, the power supply is deactivated rendering laser operation impossible. In the ON position, the power supply and CPUs are activated providing full system control through the remote control module or computer interface. All system status indicators and interlocks are activated and the power supply fan will be on. As long as the keyswitch is on, the light pick-off remains thermally stabilized.



Key:
1 LED Indicators (6) 2 System Keyswitch

Figure 7. INNOVA 310/320 Series Ion Laser Power Supply, Front View.

High voltage is present in the power supply, even with the keyswitch in the OFF position.

Indicator Lights

There are six LED indicators located on the front of the power supply which will illuminate whenever the system keyswitch is in the ON position. When lit, these LEDs indicate proper operation of the following internal voltage supplies: HK POWER, +15 V, -15 V, +5 V CPU, CPU and ±15 V CPU. These LEDs should be illuminated whenever the system keyswitch is in the ON position. If any LEDs are out, suspect a fault and refer to Chapter Eight, Maintenance and Troubleshooting.

MY TALK ADDRESS Dip Switches

A small dip switch panel is located on the rear panel of the power supply labelled MY TALK ADDRESS. If the system is connected to an IEEE 488 computer interface bus, switches 1 through 5 determine the laser's talk address (Chapter Nine, External Computer Control of the INNOVA 310/320 Series Ion Laser). Switch 8 determines the number of menus available on the remote control module. In the down (OFF) position, only the standard menus are accessible. In the up (ON) position, the extended menus will be accessible. Switches 6 and 7 are reserved for future applications.

Remote Control Module

The remote control module (control panel for the INNOVA 310/320 Series Ion Laser) is connected to the power supply by a 4.9 m (16 ft.) telephone cable. The remote control module features pushbutton controls, a Liquid Crystal Display (LCD), a LASER EMISSION indicator and four LEDs.

Laser Emission Indicator

When the ON/OFF button is pressed to start the laser, the LASER EMISSION indicator on the remote control module will illuminate to warn that the laser will soon ionize. This indicator will remain illuminated until the laser is shut off.

Default Display

The default display appears on the LCD when the system keyswitch is first turned on. The display will remain in the default display unless MENU, TUNE or MEMORY is pressed. MENU, TUNE and MEMORY displays can only be entered from the default display.

With the system keyswitch ON but the laser off, the default display will read:

```
Laser Off
Turn On:      10.0A
```

The first line will indicate laser off or a fault message will appear if a fault exists (refer to Chapter Eight, Maintenance and Troubleshooting). The second line will indicate the current or power level at which the laser will start depending on whether the system is in Current Regulation Mode or Light Regulation Mode.

When the ON/OFF button is pressed, the first line of the display will change to:

```
Start Delay:    30
```

The number indicates the time in seconds remaining before the tube ionizes and will count to zero before the laser starts.

When the laser is on, the default display will appear as follows:

```
10.0A 0.57W    CUR
MLVS         PTOFF
```

Key:
1 Liquid Crystal Display 2 Scroll Buttons

Figure 8. INNOVA 310/320 Series Ion Laser Remote Control Module Panel.

The first line is divided into three fields which display tube current, laser output power, and operating mode. The operating mode will read **CUR** if in current regulation, **LT** if in standard light regulation or **LT-** if in reduced bandwidth light regulation. In current regulation, the tube current is locked to a constant value set by the operator and the output power is monitored. In light regulation, the output power is locked to a constant value set by the operator and the tube current is monitored. Refer to Chapter Five, Guide to Daily Operation for an expanded explanation.

The second line of the default display is also divided into three fields. The first field indicates the wavelength calibration of the internal power monitor. The center field is blank unless operating in a memory mode. If a memory setting is used, the center field will display either **MEM1** or **MEM2** to indicate the memory level. For systems equipped with PowerTrack, the third field indicates whether PowerTrack is on or off by displaying either **PTON** or **PTOFF**.

To return to the default display from any menu level, press the MENU button until the default display appears. To return from memory selection or tune mode, press the MEM or TUNE button.

FAULTS

The microprocessor in the INNOVA 310/320 Series Ion Laser power supply constantly monitors operating parameters for faults whenever the keyswitch on the power supply is ON. If a fault is detected, the system will shut down and a fault message will appear on the remote control module LCD (refer to Chapter Eight, Maintenance and Troubleshooting). The ON/OFF button will not start the laser until the fault is corrected. When the fault is corrected, press the ON/OFF button or turn the system keyswitch off then on to reset the display and/or start the laser.

PUSHBUTTON CONTROL—DEDICATED BUTTONS

There are ten pushbuttons on the remote control module to allow the operator to control and monitor the INNOVA 310/320 Series Ion Laser. Five buttons are dedicated to specific functions: ON/OFF, MEMORY, TUNE, PWR TRK and LIGHT. A description of these buttons follows. The scroll buttons operate both independently and in conjunction with other buttons. These control sequences are described fully in Chapter Five, Guide to Daily Operation.

UPSCROLL/ DOWNSCROLL

Located to the right of the ten pushbuttons are two buttons marked with up and down arrows. These are the UPSCROLL and DOWNSCROLL BUTTONS—referred to as the scroll buttons. When either the default or tune display modes are

operative, the scroll buttons are used to adjust the current setting (current regulation) or the power output setting (light regulation). If the memory function is activated, the scroll buttons are used to toggle between the two memory settings. When in a menu display, the scroll buttons enable the user to scan through the various menus or through a selection of settings for a particular menu once SELECT has been pressed.

ON/OFF

The ON/OFF button turns the laser on or off. At initial turn on there is a 30-second delay after the main contactor closes before the tube starts. If the laser is turned off and then immediately on again, there is an additional 10-second delay before the contactor closes again. The ON/OFF button will operate at all times from any display mode.

MEMORY

The MEMORY button activates the memory functions and its LED lights up when activated. The MEMORY button is only operational from the default display. There are two memory modes available: store and recall.

The store function saves preset operating levels for Light or Current Regulation Modes. Two settings can be saved in memory at any one time. These settings are automatically titled **MEM1** and **MEM2** by the CPU. A setting can be saved as follows:

1 Set the laser to the desired operating mode and power level.

2 Press the MEMORY button. The memory LED will light and the second line of the display will change to show the current memory settings.

3 Press the SET button. The SET LED will light.

4 To store in **MEM1**, press the UPSCROLL button. To store in **MEM2**, press the DOWNSCROLL button. The SET LED will go out.

The laser will stay at its present setting. The display will return to the default display and either **MEM1** or **MEM2** will appear on the display to indicate the level activated. The memory LED will remain on and the scroll buttons will toggle between the two memory levels. To exit memory mode, press the MEMORY button.

The recall function allows a preset memory level to be recalled. This function also allows the operator to toggle between the two preset levels using the scroll buttons. A memory setting is recalled as follows:

1 Press the MEMORY button. The memory LED will illuminate and the second line of the display will change to show the current memory settings.

2 Press the UPSCROLL or the DOWNSCROLL button to select level **MEM1** or level **MEM2**.

The laser will assume the level selected. The display will return to the default display and either **MEM1** or **MEM2** will appear on the display to indicate the memory level activated. The memory LED will remain on and the scroll buttons will toggle between the two memory levels. To exit memory mode, press the memory button.

TUNE

The TUNE button deactivates PowerTrack and Light Regulation Mode and displays a power output tuning bar to allow manual alignment of the laser mirrors. The TUNE button is only operational from the default display. Use the tuning bar to maximize power output by making resonator adjustments with the high reflector mirror tuning knobs.

The TUNE button also resets the PowerTrack solenoids to the center position of their range. This adjustment gives PowerTrack its full range again once the rear high reflector mirror is repeaked. If PowerTrack is not in the center position when TUNE is pressed, this recentering will cause an immediate power decrease that can be remedied by peaking the mirror alignment manually.

After the rear high reflector mirror has been adjusted for maximum power, press the TUNE button to return to the default display. If Light Regulation Mode was selected, the system will return to the previous light level setting. If PowerTrack was on, it will reactivate.

Light Regulation Mode always adjusts current to maintain a constant power level. PowerTrack adjusts front mirror alignment to compensate for rear mirror movement. Thus, if either of these modes are active, the tune mode must be used when making any manual adjustments to mirror alignment or removing the output mirror. Otherwise, it will be impossible to properly align the mirrors.

PWR TRK

Press the PWR TRK button to activate PowerTrack Mode. When PowerTrack Mode is selected, the second line of the LCD will display **PTON**. If PowerTrack is actively controlling the mirror position, the LED will be illuminated. If PowerTrack Mode is selected but the system is unable to control the mirror position (for example, closed aperture), the PowerTrack system will be put on hold and the LED will turn off.

If PowerTrack reaches the end of its tuning range, the system will put PowerTrack on hold and indicate the out-of-range condition with a blinking LED. In this situation, select tune mode to recenter PowerTrack. Adjust the high reflector mirror for maximum power. Once the power is maximized, press TUNE again to exit tune mode and resume PowerTrack with full range.

For optimum performance, the PowerTrack control loop can be recalibrated for a particular set of operating parameters. A calibration routine can be initiated from the default mode as follows: turn PowerTrack on and, with Light Regulation Mode off, press the SET button. During PowerTrack calibration, the output power will fluctuate rapidly. This procedure will take approximately 15 seconds and should only be used if the operating parameters are significantly changed (for example, by changing wavelength or going from low to high power).

LIGHT

Press the LIGHT button to toggle between Light and Current Regulation Modes. Light Regulation Mode is active when the LED indicator is illuminated. Use the scroll buttons to set the power level. Current Regulation Mode is active when the LED indicator is off. Use the SCROLL buttons to set the current level.

If the set output power level cannot be achieved within the current range of the system power supply when in Light Regulation Mode, the LED indicator will blink. The system will switch to current regulation and remain at the maximum current. Realign the rear mirror in tune mode or lower the set power level, then toggle the LIGHT button to return to Light Regulation Mode. If the power level setting is too low to achieve, the system will remain at minimum current. Increase the set power until the LED stops blinking to ensure proper light regulation.

PUSHBUTTON CONTROLS—MENUS

The MENU, SELECT and SET buttons in conjunction with the scroll buttons described in the previous section give the user access to a system of menus. These menus provide system status information and allow the user to set less frequently changed system parameters. This section describes both the operation of these buttons and the main menus and sub-menus.

The main menus are of two types: Standard Menus and Extended Menus. Standard menus are always accessible. Availability of extended menus depends on the setting of the dip switch in the MY TALK ADDRESS on the rear of the power supply. This topic is addressed fully in Extended Menus, below.

MENU

From the default display, press the MENU button to access the main menus. Use the scroll buttons to scan the menus until the one required appears in the display. If the menu title is followed by dots, then use the SELECT button to access sub-menus or a parameter select menu. When in a main menu, sub-menu or parameter select menu, press the MENU button to return to the next higher menu level. Repeated pressing of the MENU button will return to the default display from any menu level. Use the MENU button to exit a parameter select menu if you do not want to change the value.

SELECT

When in a main menu or sub-menu, press the SELECT button to access additional sub-menus or a parameter select menu. The menu title will be followed by dots if sub-menus or parameter selection menus are available. Use the SCROLL buttons to scan the sub-menus of any level or to scroll through the options available in a parameter select menu. Use the MENU button to return to the next higher menu level or press the SET button to set a parameter to the value currently displayed.

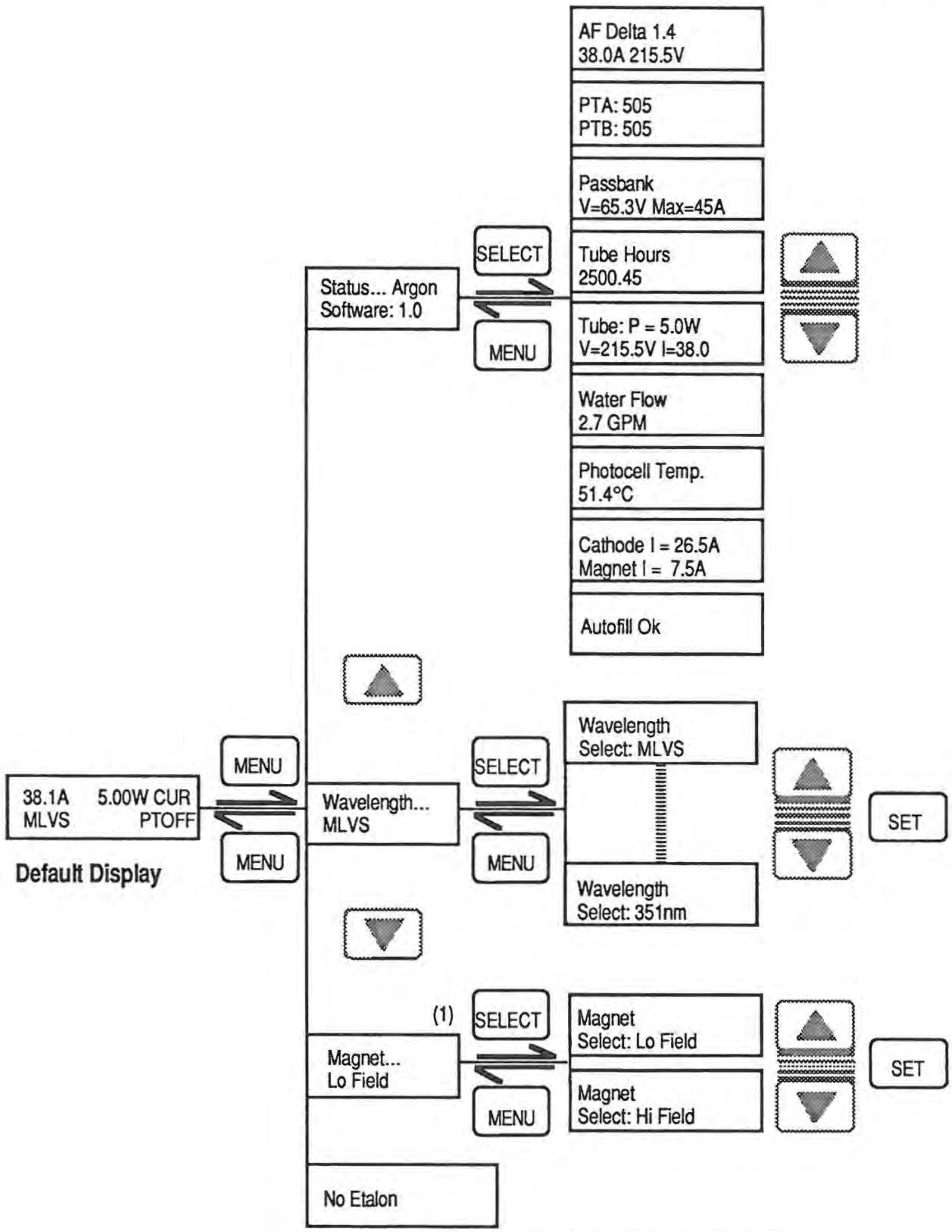
SET

The SET button is used to set a parameter to a specific value. Use the MENU and SELECT buttons to access a specific parameter select menu (that is a menu in which the second line reads **SELECT**: followed by the parameter value). Use the scroll buttons to scan the options for that parameter. When the required value is displayed, press the SET button to set this value. To exit a parameter select menu without changing the value from the previous setting, press the MENU button or press the SET button when the same value appears in the display.

The SET button is also used in conjunction with the MEMORY button to set a memory level and in conjunction with the PWR TRK button to calibrate PowerTrack (refer to the button description above).

STANDARD MENUS

The Standard Menus are always accessible from the remote control module by using the MENU, SELECT and SCROLL buttons. The menu tree in Figure 9 shows how to access each of the standard menus. Refer to Figure 9 as you read the following descriptions of these menus.



(1) Available only with the tube off.

Figure 9. Menu Tree, Standard Menus.

STATUS MENU

To select the Status Menu, press the MENU button and use the SCROLL buttons to scan through the main menu selections until the LCD shows:

```
Status...    Argon
Software:      1.0
```

The first line indicates the tube gas type. The second line gives the version number for the software which controls the main CPU in the power supply.

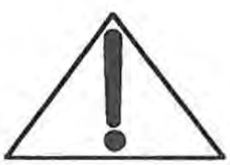
To select a sub-menu, press the SELECT button. Use the SCROLL buttons to scan the list until the sub-menu required appears in the LCD window.

Sub-menu items for the status menu and their definitions are as follows:

```
AF Delta 1.4
38.0A   215.5V
```

Displays the autofill system status. The first number is the delta of actual tube voltage minus the voltage at which the tube will need a fill. A negative delta for more than five minutes at one current setting will cause a fill cycle.

The first number on the second line is the actual tube current, the second is the tube voltage.



The autofill circuitry will only engage if the system is operating at the same current setting for five minutes at a set current or power level. If your application requires frequent changes in current, run the system at full current for fifteen minutes at least once per day. This fixed current run will allow the autofill circuitry to bring the plasma tube to the correct pressure for tube operation.

Failure to maintain correct tube gas pressure will cause an under voltage fault which will shut down the system. In addition, running the plasma tube at lower-than-normal gas pressure for prolonged periods is harmful to the tube.

```
PTA:505
PTB:505
```

PTA and PTB display the relative positions of the PowerTrack solenoids A and B (range 0-1023). Press the TUNE button to reset them to center (~511) during any alignment procedure.

```
Passbank
V=65.3V  MAX=45A
```

The first number displays the total voltage across the passbank at the present tube current. This value will be approximately the DC rectified line voltage minus the present tube voltage. The second number is the maximum DC current deliverable by the passbank of this power supply. If this

number is the same for two INNOVA 310/320 Series Ion Lasers, then the power supplies are interchangeable.

`Tube Hours`
`2500.45`

Displays the number of operating hours on the plasma tube.

`Tube:P=5.0W`
`V=215.5V I=38.0`

The first line displays the actual laser power output.
The second line displays the plasma tube voltage and the actual DC current flowing through the plasma tube.

`Water Flow`
`2.7GPM`

Displays the water flow rate in gallons per minute. A low water flow fault will occur if water flow is less than 2.2 GPM (refer to Chapter Eight, Maintenance and Troubleshooting).

`Photocell Temp`
`51.4°C`

Displays the photocell temperature. The temperature should be above 50°C (132°F) and should become stable approximately 15 minutes after the system keyswitch is turned on.

`Cathode I=26.5A`
`Magnet I=7.5A`

Shows the AC cathode current and the DC magnet current.

`Autofill Ok`

Displays Autofill status for operation of the laser below 25A. As Autofill is not active below 25A, the maximum period of low current operation is limited to 100 hours. After 100 hours of low current operation, the laser must be operated above 25A to enable the Autofill system to optimize tube gas pressure. Refer to Chapter Five, Guide to Daily Operations, for more details.

WAVELENGTH MENU

It is not necessary to change the wavelength setting on the INNOVA 310/320 Series Laser system. The correct wavelength calibration is set at the factory as follows:

318	MLVS	For multiline visible operation
325	MLUV	For multiline UV operation
326	MLUV	For multiline UV operation

Selecting a wavelength for which the system has not been calibrated may cause the tube current to increase immediately to the maximum setting. This current increase and the associated output power increase is not harmful to the laser. However, an unexpected power increase may damage other equipment you are using.

The following sequence of steps describes how the Wavelength Menu works. It is for your information only.

To select the Wavelength Menu, press the MENU button and use the SCROLL buttons to scan through the menu selections until the LCD shows:

```
Wavelength...
MLVS
```

To change the wavelength calibration for the photocell, press the SELECT button and the LCD will show:

```
Wavelength
Select:        MLVS
```

Use the SCROLL buttons to scan the available wavelengths until the desired wavelength is reached. For instance:

```
Wavelength
Select:      351 nm
```

Then press SET to store the selection in memory. Press MENU to return to default mode. The selected wavelength will remain in memory until changed.

Magnet Menu

It is not necessary to change the magnet field setting on the INNOVA 310/320 Series Laser system. The correct magnet field setting is selected at the factory as follows:

318	Lo Field
325	Hi Field
326	Hi Field

Selecting high magnetic field operation for a visible laser (310 Series) will increase the noise level of the laser beam. Selecting low magnetic field operation for a UV laser (320 Series) will dramatically reduce the output power.

The following sequence of steps describes how the Magnet Menu works. It is for your information only.

The Magnet Menu can be used to change the magnetic field. To select the Magnet Menu, press the MENU button and use the SCROLL buttons to scan through the menu selections until the LCD shows:

```
Magnet...
Lo Field
```

To select high field or low field, press the SELECT button when the laser is off and the LCD will show:

```
Magnet
Select:   Lo Field
```

Use the SCROLL buttons to toggle between **Lo Field** and **Hi Field**. Then press SET to lock the selection in memory. Press MENU to return to the default display. The selected state will remain in memory until changed.

The Magnet Field selection menu can only be accessed when the laser is turned off and the keyswitch is on.

ETALON MENU

The INNOVA 310/320 Series Ion Laser does not have an etalon option. The main menu display will read **No Etalon.**

EXTENDED MENUS

The Extended Menus are activated by adjusting the dip switch panel labelled MY TALK ADDRESS on the rear of the power supply. If access to the Extended Menus is required, move dip switch number 8 to the up (on) position. When dip switch number 8 is in the down (off) position, only standard menu items are available. The menu tree in Figure 10 shows how to access each of the extended menus. Refer to Figure 10 as you read the following descriptions of these menus.

DIAGNOSTIC MENU

Refer to Chapter Eight, Maintenance and Troubleshooting.

AUTO LT CAL is an advanced procedure, and should only be necessary under the special circumstances outlined below.

AUTO LT CAL MENU

The Auto Lt Cal Menu is accessible when the Extended Menus are activated (refer to Extended Menus, above).

The Auto Lt Cal Menu sets a flag to enable/disable automatic light regulation calibration. The wideband (normal) Light Regulation Mode requires calibration at turn on and whenever the laser current changes significantly after Light Regulation Mode has been activated. This calibration procedure momentarily modulates the laser output by 10% (worst case) at approximately 2 kHz which might disturb an ongoing experiment.

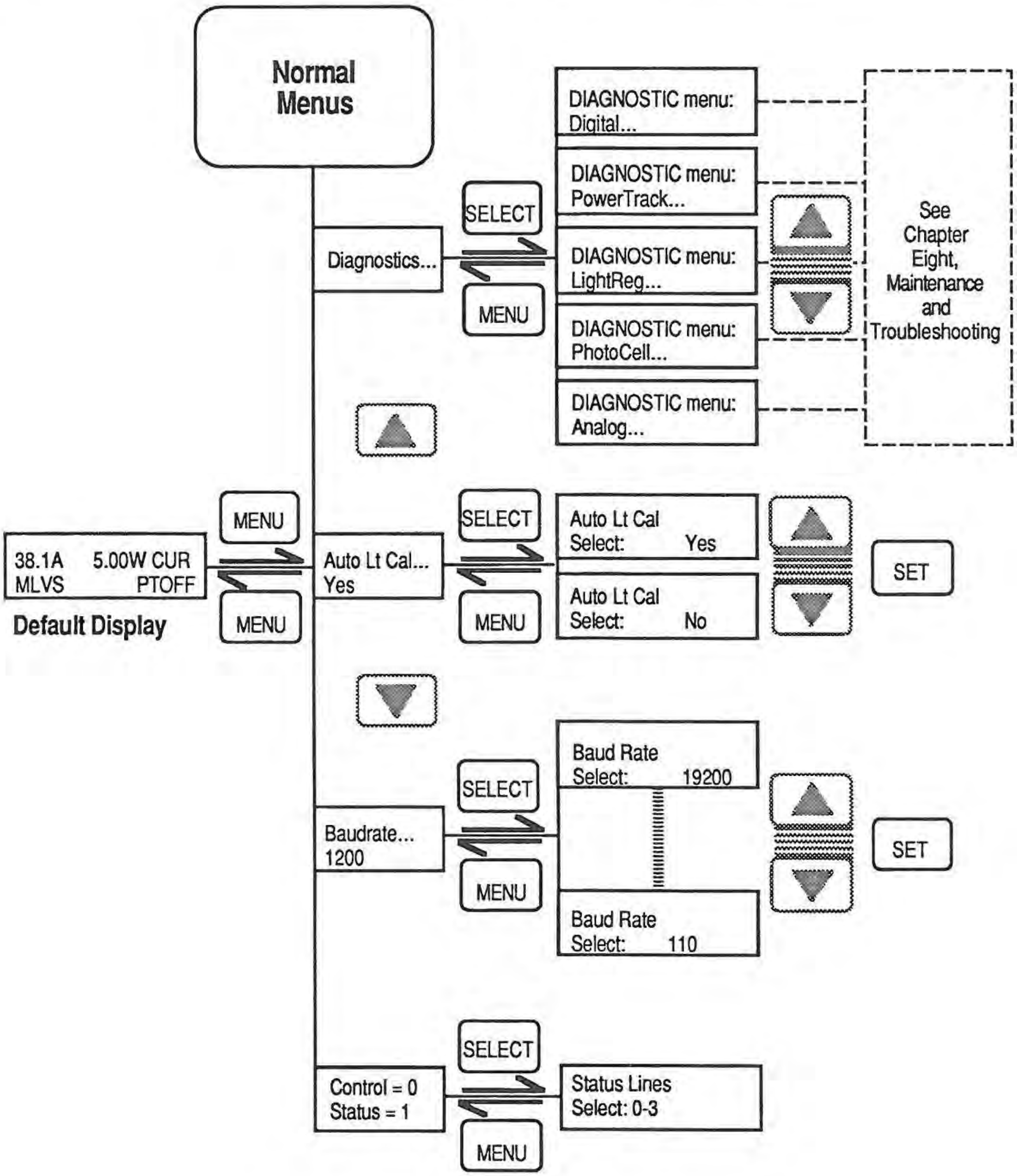


Figure 10. Menu Tree, Extended Menus.

Select the AUTO LT CAL menu by using the MENU and scroll buttons until the LCD shows:

```
Auto LT Cal...
Yes
```

Press the SELECT button and the LCD will show:

```
Auto LT Cal
Select:        Yes
```

Use the scroll buttons to toggle between **Yes** and **No**. Press SET to lock the selection in memory. Set **Yes** to enable automatic recalibration. Set **No** to disable the automatic recalibration.

If automatic calibration is disabled before entering Light Regulation Mode, the system will choose reduced bandwidth light regulation. This mode is not compatible with PowerTrack. If Light Regulation Mode is selected before disabling automatic calibration, then the system will choose wideband light regulation. If recalibration becomes necessary during operation in light regulation, the system will switch to reduced bandwidth light regulation. However, note that a recalibration condition under normal circumstances (laser system well aligned, warmed-up and meeting specifications) should rarely occur. The system runs typically in light regulation for 24 hours without changing current more than a few tenths of an amp. For more details, refer to Light Regulation Mode in Chapter Five, Guide to Daily Operation.

BAUD RATE MENU

The Baud Rate Menu is used to set the baud rate for the RS-232/422 port. This menu is accessible when the Extended Menus are activated (refer to Extended Menus above).

To set the baud rate, select the Baud Rate Menu using the MENU and scroll buttons until the LCD shows:

```
Baud Rate...
1200
```

Press the SELECT button and the LCD will show:

```
Baud Rate
Select:        1200
```

Use the scroll buttons to scan the available baud rates until the desired baud rate is reached. Then press SET to store the selection in memory. The selected baud rate will remain in memory until changed.

The baud rate is initially set at the factory to 1200. Other available baud rates are 110, 300, 4800, 9600 and 19200. The baud rate can also be changed by a command through the RS-232/422 interface. For further information on the operation of this interface, see Chapter Nine, External Computer Control of the INNOVA 310/320 Series Ion Laser.

CONTROL/STATUS MENU

Control and Status refer to the states of pins 10, 24, and 25 of the Analog Interface. These variables are also accessible through RS-232 and IEEE-488. Control is a read only variable

and shows the status of a spare input line of the Analog Interface (pin 10):

`Control = N`

N = 0 Pin 10 is low.

N = 1 Pin 10 is high.

Status provides control of the two output lines of the Analog Interface (pins 24/25):

`Status = N`

N = 0 Pin 25 low, pin 24 low

N = 1 Pin 25 low, pin 24 high

N = 2 Pin 25 high, pin 24 low

N = 3 Pin 25 high, pin 24 high

LASER HEAD CONTROLS AND INDICATORS

This section describes the controls and indicators for the INNOVA 310/320 Series Ion Laser head. Some controls are located at the front, or laser output end of the laser head, and some are located at the rear, or umbilical end, of the laser head.

FRONT

The following controls are located at the front of the laser head. Refer to Figure 11 for their location as you read the descriptions.

APERTURE CONTROL

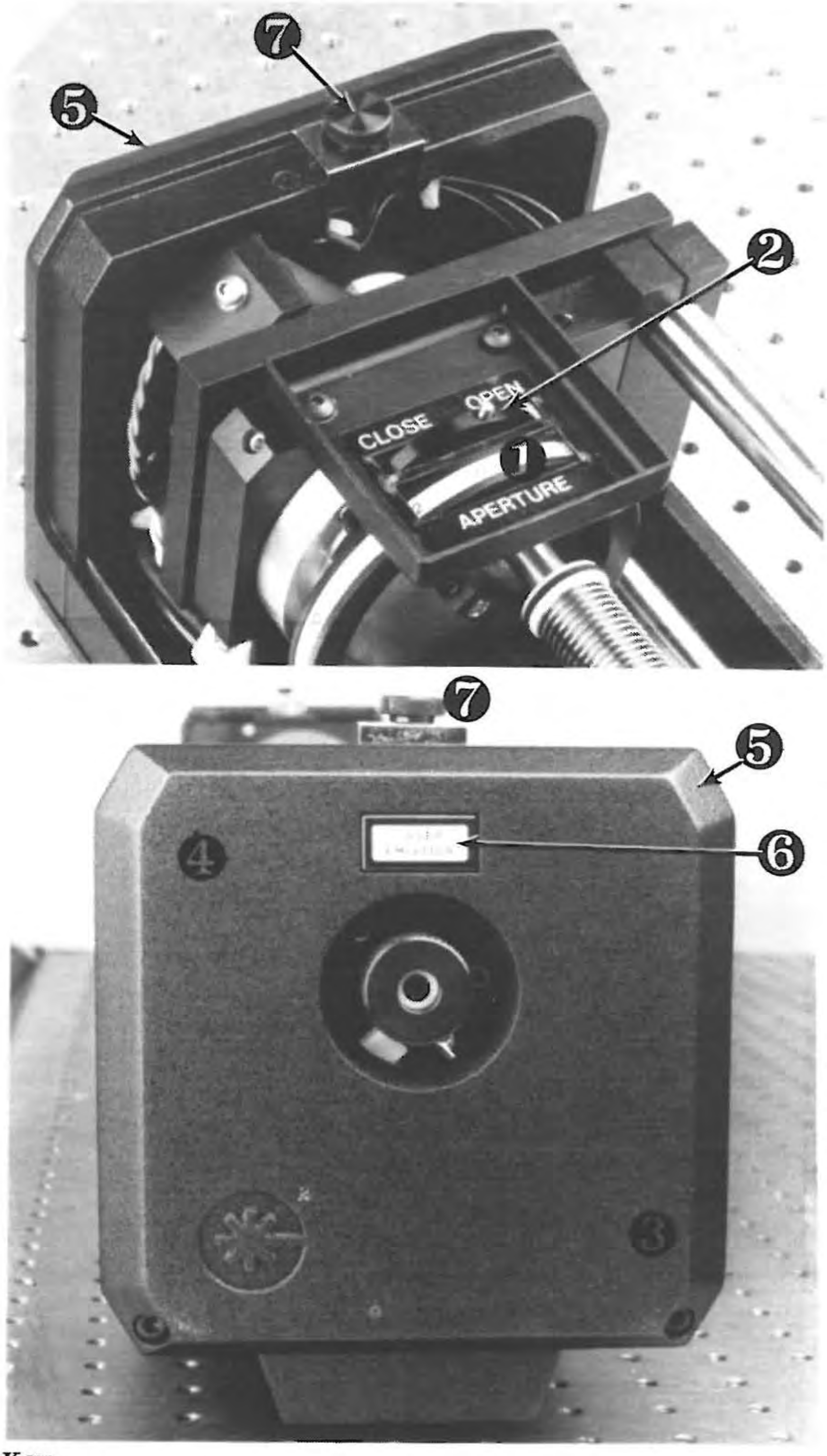
The aperture wheel is used to control the laser mode. Position O represents Open Aperture. Aperture size decreases as the wheel is rotated from position O to 1 (For more information, refer to Chapter Five, Guide to Daily Operation and Chapter Seven, Theory of Operation).

BEAM SHUTTER

In the CLOSE position, lasing action is stopped by interrupting the intracavity beam. The OPEN position permits lasing.

OUTPUT MIRROR HORIZONTAL CONTROL

A 5/32 in. Allen screw which is accessed through a hole in the lower right of the laser head front bezel adjusts the output mirror horizontally. This control should only be used in conjunction with the Coarse Mirror Alignment and Walk-In procedures (Chapter Six, Optics and Alignment).



Key:

1	Aperture Wheel	4	Output Mirror Vertical Control
2	Beam Shutter	5	Front Bezel
3	Output Mirror Horizontal Control	6	Laser Emission Indicator
		7	Head Interlock Defeat

Figure 11. INNOVA 310/320 Series Ion Laser Head Front Controls and Indicators.

Output Mirror Vertical Control

A 5/32 in. Allen screw which is accessed through a hole in the upper left of the laser head front bezel adjusts the output mirror vertically. This control should only be used in conjunction with the Course Mirror Alignment and Walk-In procedures (Chapter Six, Optics and Alignment).

Laser Emission Indicator

When the keyswitch is in the ON position and the LASER ON button has been pressed, the LASER EMISSION lamp on the front bezel will illuminate to warn that the laser will soon ionize. This indicator will remain on until the laser is shut off.

Rear

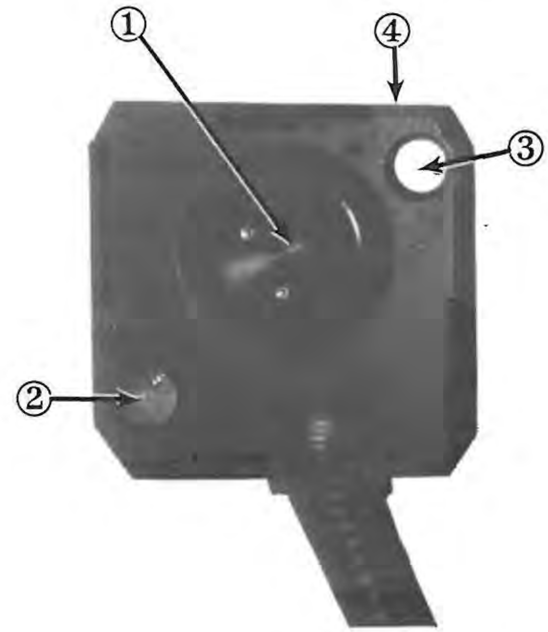
The following controls are located at the rear of the laser head. Refer to Figure 12 for their location as you read the descriptions.

High Reflector Mirror Horizontal Control

A two-speed tuning knob located at the lower left corner of the laser head rear bezel next to the umbilical adjusts the high reflector mirror horizontally. Adjust this knob only in tune mode or with Light Regulation Mode and PowerTrack off. Use it to maximize the laser power output by watching the tune bar or an external power meter.

High Reflector Mirror Vertical Control

A two-speed tuning knob located at the upper right corner of the laser head rear bezel adjusts the high reflector mirror vertically. Adjust this knob only in tune mode or with Light Regulation Mode and PowerTrack off. Use it to peak the laser power output by watching the tune bar or an external power meter.



Key:

1. Beam Block
2. High Reflector Mirror Horizontal Control
3. High Reflector Mirror Vertical Control
4. Vertical Scan Lever

Figure 12. INNOVA 310/320 Series Ion Laser Head, Rear Controls and Indicators.

INNOVA® 310/320 Series Ion Laser

Operator's Manual

Chapter Five
Guide to Daily Operation

COHERENT®

Introduction and General Information

This chapter outlines some of the most commonly used procedures required for normal operation of your INNOVA 310/320 Series Ion Laser.

For your own safety and for the safety of others, please familiarize yourself with necessary laser safety codes. It is recommended that you study Chapter Two, Laser Safety, as well as other publications on laser safety such as those listed in Chapter Two.

The autofill circuitry will only engage if the system is operating at the same current setting for five minutes. If your application requires frequent changes in current or power level, run the system for fifteen minutes at a fixed current at least once per day. This fixed current run will allow the autofill circuitry to bring the plasma tube to the correct pressure for tube operation.

Failure to maintain correct tube gas pressure will cause an under voltage fault which will shut down the system. In addition, running the plasma tube at lower-than-normal gas pressure for prolonged periods is harmful to the tube.

Automatic Shutdown

In order to assure optimum laser performance at any current setting throughout the life of the laser tube, the autofill circuitry will not give gas fills to the tube when the tube operating current is below 25 amps. The laser may be operated below 25 amps for 100 hours before a fill sequence is required. At the end of 90 hours, the system CPU transfers to the Status Menu to display the following warning message on the LCD:

```
Low I Shutdown
in 10 hours
```

Press the Menu button to leave the Status Menu and return to the default display. The laser may be operated for an additional 10 hours at a current below 25 amps. At the end of 100 hours, the system will automatically shut down. The LCD will display this message:

```
Low I Shutdown
Start at 30 Amps
```

To restart the laser, press the remote module On/Off button. Adjust the tube current setting to 30 amps while the laser is in Start Delay. As an alternative, you many turn the system keyswitch off and then on again to clear the display. Then adjust the current setting to 30 amps and restart the laser.

Allow the system to run at 30 amps while the fill system brings the laser to the required operating voltage. This process may require from 5 to 45 minutes.

Avoiding an Automatic Shutdown

To avoid the inconvenience of an automatic shutdown, increase the laser current to a setting above 25 amps. Let the system run at this setting for 45 minutes to allow the fill system to adjust the tube voltage.

System Status

To find out how much operating time remains before Automatic Shutdown will occur, enter the Status Menu and scroll through it until the display shows:

Low I Shutdown
in XX hours

During the first 10 hours of low current operation, the display will read:

Autofill Ok

When an Automatic Shutdown occurs, the Status Menu display will read:

Low I Shutdown
in 0 hours

This message will be displayed until the autofill cycle is completed and the system is available for normal operation. When the laser tube is restored to optimum voltage and pressure conditions, the Status Menu display will read:

Autofill Ok

If the laser system shuts down for a reason other than **Low I Shutdown**, the default menu will display the fault (**Low Pressure**, for example).

RS-232/IEEE-488 Operation

Automatic Shutdown information is available through the RS-232 or IEEE-488 computer control interface. To find out how much operating time remains before Automatic Shutdown will occur, send the query **PRINT HRSTILSHUTDOWN** to the laser system. The number returned by this query is the time remaining in hours until Automatic Shutdown. The laser system will return **100** to indicate an **Autofill Ok** condition. (Refer to Chapter Nine, External Computer Control.)

START-UP PROCEDURE

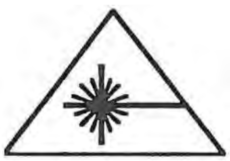
Use the following procedure to start your INNOVA 310/320 Series Ion Laser.

1 Establish the flow of cooling water to the laser. Open the drain valve before opening the supply valve to prevent over-pressurization of the cooling system.

2 Place a power meter or beam stop in front of the laser head to block the laser beam.

3 Turn on the main wall circuit breaker for line power.

4 Turn the keyswitch located on the front panel of the power supply to the ON position. Wait for the remote control module to power up. All LEDs on the front panel of the power supply should be illuminated.



Argon laser safety glasses should be worn throughout this procedure.

5 Press the ON button to initiate the START DELAY cycle. The remote control module will read **Start Delay** and the LASER EMISSION warning light on the remote control module will be illuminated. The plasma tube will ionize and conduct current after a 30-second delay. Lasing can occur immediately upon tube ionization.

6 If lasing does not occur when the tube ionizes, check that the beam shutter is open. If open, follow the Vertical Search Procedure in Chapter Six, Optics and Alignment.

WARM-UP TIME

It takes approximately one hour for the INNOVA 310/320 Series Ion Laser resonator to become thermally stabilized. Typically though, from day-to-day, the resonator will come to more than 97% of its previous power level within 30 minutes of turn on. Horizontal and vertical adjustments to the high reflector mirror tuning knobs may be required to achieve optimum output power if PowerTrack is not engaged. For best results, adjust the laser to maximum power after the initial 30-minute warm-up. With PowerTrack, warm-up time to specified power is 60 seconds.

Shut-Down Procedure

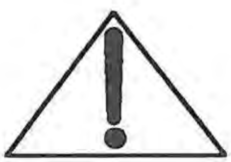
Use the following procedure to shut down your INNOVA 310/320 Series Ion Laser.

1 Press the ON/OFF button on the remote control module. This will disengage the power supply main contactor and shut off the plasma tube.

2 Switch off all power to the digital electronics and the remote control module by turning off the keyswitch.

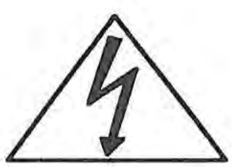
This step may be skipped if you wish to maintain thermal stabilization of the light pick-off. This will provide optimum start up performance if starting in Light Regulation Mode.

3 To prevent thermal stress to the tube, allow the cooling water to flow for at least five minutes after the laser is shut down. Shut off the water by closing the supply valve first, then the drain valve, to prevent over pressurization of the cooling system.



Sudden water failure should not damage the plasma tube. However, thermal stress to the plasma tube caused by water failure should be avoided.

To help prevent condensation from forming on the power supply passbank heatsink, turn the cooling water off when the laser is not in use (approximately five minutes after shut down).



Switching on the laser when condensation is present on the passbank heatsink could cause catastrophic failure to the power supply.

4 Turn off the main wall circuit breaker, unless the power supply is to remain on (step 2).

Last Operating Parameters Memory

When the INNOVA 310/320 Series Ion laser is shut down, the last used operating parameters are stored in memory. When the laser is restarted, these settings will be automatically reactivated.

The following is a list of the user changeable parameters stored for reactivation at start-up:

1 Operating mode—Light or Current Regulation Mode

2 Current or Light level

3 PowerTrack status—ON or OFF

4 Wavelength setting for photocell calibration

5 Magnet Field—High or Low Field

6 Baud rate

The laser will start at the same level and operating modes as when it was shut down unless the settings are changed manually before shutdown or before tube ionization. Note that you cannot change from Current Regulation to Light Regulation Mode when the laser is off.

If the laser is shut off directly with the keyswitch, the last operating parameters will remain in short-term memory for three days. If you use the ON/OFF button to deionize the laser before turning off the keyswitch, the system will store parameters 3 through 6 in long-term memory indefinitely.

Maximizing Output Power

Tuning the INNOVA 310/320 Series Ion Laser for maximum output power is accomplished by adjusting the high reflector mirror vertical and horizontal tuning knobs. The laser must be lasing to successfully complete this procedure.

1 For lasers with PowerTrack engaged, the output power will be maximized automatically. Tuning will only be necessary should PowerTrack reach the limit of its control range. If this occurs, follow the procedure in step 2.

2 For lasers with PowerTrack disengaged, use the following procedure:

   a Allow the laser to warm up and stabilize at the intended operating current for at least 30 minutes.

   b Press the TUNE button on the remote control module.

   c Adjust the high reflector mirror horizontal and vertical tuning knobs for maximum laser power indication on the remote control module or on an external power meter.

   d Press the TUNE button again to return to the previous setting.

PowerTrack

PowerTrack is an active stabilization loop that automatically maintains optimum cavity alignment by servo control of the output mirror. To assure proper performance, use the procedures described below when operating with PowerTrack.

HOW TO ACTIVATE POWERTRACK

To activate PowerTrack at any time during operation, press the PWR TRK button on the remote control module.

To ensure optimum laser start-up and long-term performance from PowerTrack, set up PowerTrack at the center of its range using the following procedure.

1 Allow the laser to warm up after start-up for at least 30 minutes.

2 Press the TUNE button.

3 Maximize the output power of the laser by adjusting the horizontal and vertical high reflector mirror tuning knobs. Press TUNE again to resume normal operation.

4 Press the PWR TRK button on the remote control module so that the LED is illuminated and **PTON** is displayed at the bottom right of the LCD on the remote control module.

PowerTrack will now keep the laser output power optimized and warm-up time to a minimum.

If PowerTrack reaches the limit of its control range, the LED on the remote control module will flash. This condition can be corrected by entering tune mode and retuning the high reflector mirror.

If PowerTrack cannot actively control the laser power (e.g. if the shutter is closed or the system is in Reduced Bandwidth Light Regulation), the PWR TRK LED will go off.

POWERTRACK CALIBRATION

For optimum performance for a particular wavelength or power level, the gain of the PowerTrack control loop can be calibrated. To initiate a calibration routine:

1 Maximize the output power in the tune mode by adjusting the high reflector mirror horizontal and vertical tuning knobs. Press TUNE to resume normal operation.

2 Turn PowerTrack on.

3 Turn Light Regulation Mode off.

4 Press SET when in the default display.

The output power will fluctuate rapidly during calibration (about 15 seconds), then PowerTrack will resume. The calibration loop gain will be stored in memory.

START-UP PROCEDURE WITH POWERTRACK

If PowerTrack is on when the laser is shut off, it will be automatically reactivated at next start-up.

1 Follow steps 1-5 of the Start-Up procedure.

2 Once the plasma tube is ionized and the laser is lasing, PowerTrack will maximize the output power.

Controlling the Power Output

The INNOVA 310/320 Series Ion Laser can be operated in either Current Regulation Mode or Light Regulation Mode. In current regulation, the system maintains a fixed current level set by the user. In light regulation, a precise output power level set by the user is maintained by a light feedback control loop.

To toggle between Light and Current Regulation Mode, press the LIGHT button on the remote control module. The laser may be switched between these two modes at any time during operation. Use the SCROLL buttons to set the desired current or power level when in the default mode. Read the following sections for a detailed description of each of these operating modes.

Current Regulation Mode

When the laser is in Current Regulation Mode, the plasma tube current is kept constant. The LED above the LIGHT button on the remote control module will be off and the LCD will display **CUR** in the top right-hand corner of the default display.

Use the SCROLL buttons to adjust the tube current setting to the desired level.

In Current Regulation Mode, the tube current will not change if the intracavity optical beam path is interrupted or misaligned. The laser should be run in Current Regulation Mode when adjusting mirror alignment or changing optics. When the TUNE button is pressed, the tune mode automatically switches the laser to Current Regulation Mode. It is recommended that the tune mode be used when mirror alignment or optics changes are necessary.

Light Regulation Mode

When the laser is in Light Regulation Mode, the laser output power is held to a fixed level. To enter Light Regulation Mode, press the LIGHT button on the remote control module. The LED on the LIGHT button will illuminate and **LT** or **LT–** will appear in the top right corner of the default display on the remote control module. If the LIGHT LED is off, the system is operating in Current Regulation Mode.

Use the SCROLL buttons to adjust the light power output setting.

The INNOVA 310/320 Series Ion Laser should be used in Light Regulation Mode whenever precise control of the output power is required. The laser cannot be operated in Light Regulation Mode within approximately 5% of maximum current because the system needs adequate room to adjust the current for changing light output.

The laser output is measured using a temperature stabilized photocell. The photocell generates a signal which is fed back to control electronics which adjust the tube current to maintain a set laser output power.

Whenever light regulation reaches maximum or minimum tube current, an out-of-range condition will be indicated by a flashing LIGHT LED on the remote control module. The system will automatically switch over to Current Regulation Mode until it receives enough laser power to switch back to Light Regulation Mode (for instance, after retuning or cleaning). In order to switch back to Light Regulation Mode, the system requires 5% more actual power than the requested power to ensure enough current margin and to prevent oscillation. Realign the high reflector mirror in tune mode or change the set power level, then toggle the LIGHT button to return to Light Regulation Mode.

Closing the intracavity shutter while the laser is in Light Regulation Mode will cause the current to go to maximum.

With the INNOVA 310/320 Series Ion Laser, light regulation is possible in either of two modes: Standard Light Regulation Mode (LT) or Reduced Bandwidth Light Regulation Mode (LT-). The above description applies to either mode. Standard light regulation provides the maximum performance and is the default mode unless an error is encountered during automatic gain calibration or the user disables automatic gain calibration. For further description, see below.

Bandwidth	2 kHz +/- 10% (standard mode) Variable 10 Hz - 2 kHz (reduced bandwidth mode)
PowerTrack Compatibility	Yes (standard mode) No (reduced bandwidth mode)
Modulation signal required	Yes (standard mode) No (reduced bandwidth mode)
Modulation signal frequency	2 kHz
Modulation signal amplitude	5%-10% of CW power level
Modulation signal duration	1 second (nominal)
Modulation signal latency period	1 second (nominal)

Table 10. Summary of Light Regulation Characteristics.

Standard Light Regulation

Under certain conditions in Standard Light Regulation Mode, the output laser beam is momentarily modulated by 5-10% at 2 kHz. If this poses a problem for your application, read this section carefully.

Standard light regulation provides a control loop that suppresses beam noise at frequencies up to 2 kHz. To maintain this loop bandwidth, the circuit must recalibrate its loop gain whenever light regulation is first activated, when the power level is changed, or when the tube current changes by more than 20% (Automatic Light Calibration, below). The laser is in standard light regulation when **LT** appears in the top right corner of the default display on the remote control module. When an automatic gain calibration occurs, the laser will momentarily switch to reduced bandwidth regulation and **LT–** will appear in the remote control module display. If the automatic gain calibration is a problem, it may be disabled (refer to Disabling Automatic Gain Calibration, below). Once disabled, if a gain calibration becomes necessary, the laser will instead switch to Reduced Bandwidth Calibration Mode (description below).

PowerTrack can be used simultaneously with standard light regulation, but is not compatible with reduced bandwidth light regulation. When the laser switches momentarily to reduced bandwidth light regulation during automatic gain calibration, PowerTrack will be momentarily parked and its LED will be off.

Automatic Gain Calibration

The INNOVA 310/320 Series Ion Laser Standard Light Regulation Mode has been designed to suppress beam noise at frequencies up to 2 kHz. To achieve this suppression while maintaining stability of the light regulation servo loop, the gain of the servo loop must be set to its optimum value by the system software. This optimum gain value depends on the laser operating conditions and is determined by means of an automatic gain calibration routine built into the system software. During execution of this routine, the output laser beam is modulated at 2 kHz for a period of approximately 1 second. The amplitude of the modulation is typically 5% of the total output power and in the worst case is approximately 10%. Gain calibration is performed automatically by the system when any condition in Table 11 is true.

1	The operating mode of the laser is changed from current regulation to light regulation. The modulation signal will appear on the beam after a nominal 1 second delay.
2	The light power setting is changed while the laser is in light regulation mode. The modulation signal will appear on the beam after a nominal 1 second delay.
3	The laser is operating in Light Regulation Mode and the tube current has changed by 20% or more since the last execution of the automatic gain calibration routine. This will occur very infrequently during hands-off operation. A laser that is properly aligned, fully warmed up, meeting all specifications, and left undisturbed in a stable environment will operate for extended periods (typically 24 hours or more) without requiring gain calibration.

Table 11. Conditions Requiring Automatic Gain Calibration.

Disabling Automatic Gain Calibration

The system software allows the automatic gain calibration feature to be disabled through a remote module menu selection (AUTO LT CAL). When the system requires a gain calibration (Table 11) but is disabled from executing the routine, a Reduced Bandwidth Light Regulation Mode is entered. This mode, which should be used only for those applications that cannot tolerate the momentary presence of the modulation signal, is detailed below.

Disabling the automatic gain calibration does not necessarily require operation at reduced bandwidth. The following procedure places the laser in Standard Light Regulation Mode but eliminates the possibility of the modulation signal appearing on the beam:

1 Ensure that automatic light calibration is initially enabled (use the AUTO LT CAL menu to SELECT and SET the flag to **Yes**) and that the laser is in Standard Light Regulation Mode.

2 Disable automatic light calibration (set the AUTO LT CAL flag to **No**). The laser will remain in Standard Light Regulation Mode until a gain calibration is needed (Table 11), at which time it will automatically reduce the light regulation bandwidth.

Error Detection During Automatic Gain Calibration

During execution of the automatic gain calibration routine, the system intercepts certain error conditions. In the event of such an error, the system automatically enters the Reduced Bandwidth Light Regulation Mode as described in the following section. This change can occur even though the AUTO LT CAL function is enabled. Should this event occur, toggle the LIGHT button to current regulation then back to light regulation to cause an automatic recalibration.

Reduced Bandwidth Light Regulation

Reduced bandwidth light regulation provides a control loop within a variable bandwidth that is greater than 10 Hz.

When the system is operating in light regulation with reduced bandwidth:

- The remote module display will read **LT-** in the upper right hand corner (the display reads **LT** in the standard mode).
- PowerTrack will not operate. If the PowerTrack function is enabled, the remote module display will read **PTON**, but the LED above the PWR TRK button on the remote module will be off.
- The bandwidth of the laser noise suppression is variable and depends on the laser operating conditions. It is nearly always greater than 10 Hz and may approach 2 kHz in some cases.

To force operation in reduced bandwidth light regulation, proceed as follows:

1 Ensure that the laser is in Current Regulation Mode and that automatic light calibration is disabled (use the AUTO LT CAL menu).

2 Select Light Regulation Mode.

There are three circumstances under which reduced bandwidth light regulation becomes operational:

Case I is the basis of the procedure just described. The laser will operate in reduced bandwidth light regulation when the following three conditions are all true:

1 The AUTO LT CAL menu selection is set to NO;

2 Light Regulation Mode is in effect;

3 After automatic gain calibration was disabled, the system required a gain calibration as defined in Table 11.

Case II is a transient situation that exists immediately following an operator adjustment to the laser. The laser will return to standard light regulation within approximately 2 seconds. This occurs when the AUTO LT CAL menu selection is set to ENABLE and one of the following conditions is true:

1 The operator changes from current regulation to light regulation;

2 The operator changes the light power setting while in Light Regulation Mode;

3 The operator makes significant adjustments to the laser optical alignment while in Light Regulation Mode.

Case III is an operating fault. The laser automatically enters reduced bandwidth light regulation when the following three conditions are all true:

1 The AUTO LT CAL menu selection is set to ENABLE;

2 Light Regulation Mode is in effect;

3 An error has occurred during the execution of the automatic gain calibration routine (refer to Error Detection During Automatic Gain Calibration, above).

Wavelength Calibration

The INNOVA 310/320 Series Ion Laser uses a silicon photodetector to measure the output power. The detector sensitivity varies with wavelength. When the system power meter is calibrated at the factory, a calibration constant is stored for each wavelength or range of wavelengths. To maintain a calibrated display of output power on the remote control module and ensure optimum operation of light regulation and PowerTrack, the wavelength on the remote control module default display should be set to match the actual lasing wavelength. It is not necessary to change the wavelength setting on the INNOVA 310/320 Series Laser system. The correct wavelength calibration is set at the factory. Refer to Chapter Four, Wavelength Menu, for more information.

Spatial Profile of the Output Beam

The spatial profile of the laser output beam is the intensity distribution across the beam diameter. This is determined by the transverse modes of the laser cavity that are oscillating. Refer to Chapter Seven, Theory of Operation, for a further discussion of these modes. If the spatial profile is important in your application, the aperture control at the front of the INNOVA 310/320 Series Ion Laser can be used to control the transverse mode. The following sections describe how to measure and control the spatial profile on the INNOVA 310/320 Series Ion Laser.

Measurement of the Spatial Profile

Certain procedures require inspection of the transverse spatial profile of the laser beam, sometimes referred to as the mode of the laser. The simplest profiles have standard designations (e.g., TEM_{00}, TEM_{01}*, etc.) given in optics textbooks and summarized in Chapter Seven, Theory of Operation.

Several methods are available for checking the spatial profile of laser beams which vary widely in their cost and accuracy. These are:

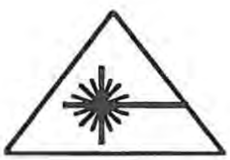
1 Visual inspection.

2 Scanning and recording the beam intensity profile.

3 RF spectrum analysis of the beat frequencies between cavity transverse modes.

For alignment and maintenance of the INNOVA 310/320 Series Ion Laser, visual inspection methods provide adequate diagnostic information and have the virtues of low cost and ease of use. For more details on beam scanning, RF spectrum analysis, or Coherent ModeMaster M^2 meter use, call Coherent Technical Support.

Visual inspection of the spatial profile requires expanding the beam to a diameter of 10 cm or more so that details can be easily seen. This expansion is accomplished using a lens or mirror of focal length 1.5-3 cm to project the beam onto a wall or screen.



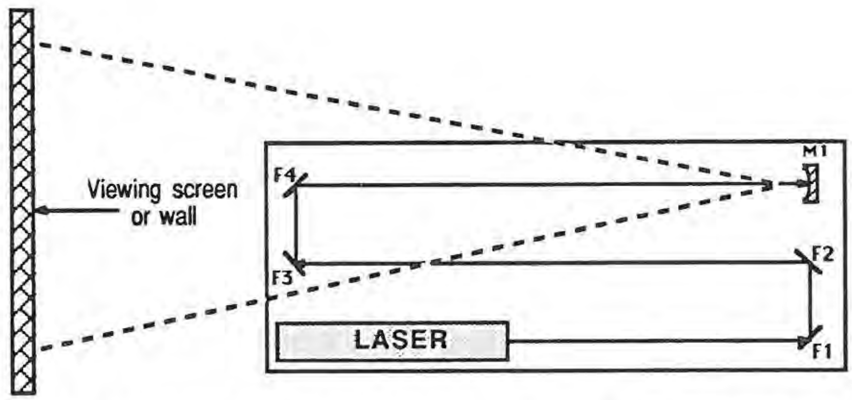
It is unsafe to hold the inspection optic in the beam by hand. CLOSE the beam shutter before placing the optic in the beam. Do not open the shutter until the optic has been secured.

Use extreme caution when projecting the laser beam in this fashion. The expanded beam is sufficiently intense to cause severe ocular damage. All personnel in the area must wear appropriate protective eyewear.

While this method is easy to use, misleading results will occur if the inspection optic is placed too close to the output mirror of the laser. Diffraction of laser light by the limiting aperture will impose a pattern of dark concentric rings on the output beam. The contrast between these dark rings and the surrounding bright areas decreases with distance from the laser head. At 5 m or more from the laser head, the rings can no longer be seen. To avoid these diffraction rings, place the inspection optic at least 5 m from the output mirror.

Diffraction rings produced by the laser aperture are not normally a cause for concern. Although these rings do produce intensity distortions in the transverse profile of the laser beam, these distortions disappear in the far field, for instance, as the beam propagates through space or, more commonly, as the beam is focused. The spatial profile viewed using the setup shown in Figure 13 will, in most cases, be an accurate representation of the transverse inten-

sity profile even if the beam is focused to a spot at distances much closer to the laser.



F1-F4: Fold mirrors to extend optical path — M1: 2 cm radius of curvature mirror
Total path from laser head to M1: ≥ 5 meters

Figure 13. Set-up for Viewing Laser Spatial Profile.

USING THE APERTURE TO CONTROL THE SPATIAL PROFILE

The aperture assembly is located near the front of the laser head next to the shutter (Figure 14). There are 12 graduated apertures and a large aperture (open aperture) that is used for alignment. The apertures are marked along the rim of the aperture wheel and decrease in size from 12 to 1 (Table 12).

The apertures are used to control the transverse mode of the laser. When the correct aperture size is selected, the laser is forced to run in a single transverse mode (refer to Chapter Seven, Theory of Operation). The aperture size required for TEM_{00} operation is dependent both on the wavelength and on the laser gain at that wavelength.

Adjust the aperture by rotating the wheel until it locks into a new position. Observe the spatial profile of the laser beam using one of the above listed methods. Adjust sequentially from largest to smallest aperture until the desired mode is achieved. For highest power output, use the largest aperture that still maintains TEM_{00}.

If unable to observe the spatial profile, use the setting determined visually at the factory and recorded on the system data sheet supplied with the laser. If mode quality is unimportant, use the open aperture setting.

The output power should decrease gradually as smaller and smaller aperture holes are selected. If not, the aperture may need aligning. Aperture alignment is discussed in Chapter Six, Optics and Alignment.

Figure 14. Aperture Wheel.

APERTURE SETTING	INNOVA 310 DIAMETER (in.)
O	0.1540 ± 0.0005
12	0.1250 ± 0.0005
11	0.1200 ± 0.0005
10	0.1160 ± 0.0005
9	0.1130 ± 0.0005
8	0.1110 ± 0.0005
7	0.1083 ± 0.0005
6	0.1065 ± 0.0005
5	0.1040 ± 0.0005
4	0.1015 ± 0.0005
3	0.0995 ± 0.0005
2	0.0980 ± 0.0005
1	0.0965 ± 0.0005

APERTURE SETTING	INNOVA 320 DIAMETER (in.)
O	0.1562 ± 0.0005
12	0.1100 ± 0.0005
11	0.1065 ± 0.0005
10	0.1040 ± 0.0005
9	0.1015 ± 0.0005
8	0.0995 ± 0.0005
7	0.0980 ± 0.0005
6	0.0960 ± 0.0005
5	0.0935 ± 0.0005
4	0.0890 ± 0.0005
3	0.0860 ± 0.0005
2	0.0820 ± 0.0005
1	0.0785 ± 0.0005

Table 12. Aperture Sizes.

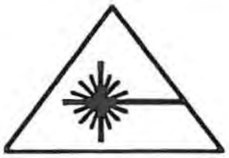
INNOVA® 310/320 Series Ion Laser

Operator's Manual

Chapter Six
Optics and Alignment

COHERENT.

This chapter is divided into three sections: care and cleaning of optics, removing and changing optics and optical alignment procedures.



Certain procedures listed in this chapter require the operation of the laser with the head cover removed and interlock defeats in place. To protect against reflected beams which will exit the laser cavity, ensure that laser safely glasses or goggles, which protect against the wavelengths used, are worn at all times during laser operation.

Figure 15. Rear Bezel of Laser Head Showing the Location of the Magnet Ground.

When the laser head cover is removed, a contact lever is exposed on the side of the rear bezel of the laser head (Figure 15). This lever is the magnet ground — not an interlock. Do not defeat this lever as to do so will create a shock hazard to personnel and may result in serious damage to the power supply. Operation of the laser will not be affected when contact is broken by removing the cover.

wet portion of the lens paper on the optic surface and slowly drag it across the optic (Figure 16). The lens paper and optic should be dry before the drag is complete.

2 Examine the surface of the optic in different lights for streaks of film. If streaks remain, repeat the process using a fresh lens paper.

On the side of each Coherent optic a small arrow (>) is printed. This arrow denotes the side that must point toward the laser cavity.

3 Re-insert the optic, being careful not to scratch the mirror surface.

HEMOSTAT AND LENS - PAPER METHOD

The Hemostat and Lens Paper method is used to clean the beam pick-off and Brewster window.

Figure 17. Cleaning an Optic (beam pick-off) using the Hemostat and Lens Paper Method.

1 Fold a lens paper into a 1 cm (3/8 in.) wide strip, being careful not to touch the portion of the paper that will contact the optic.

2 Fold this strip upon itself twice and grasp near the fold with clean hemostats as shown in Figure 17.

3 Place a few drops of methanol on the fold and shake off the excess.

4 Make a single wipe across the surface of the optic. Do not re-use the lens paper as particles of dust and other contaminants picked up from the surface may scratch the surface if dragged across with a second wipe.

OUTPUT MIRROR

Since Coherent ion laser output mirrors are made with a 0.5° wedge between the coated and exit faces (Figure 18), rotation of the output mirror will slightly change the direction of the output beam. To prevent rotation of the mirror and to maintain a consistent orientation of the wedge angle, the output mirror is mechanically keyed to the mirror holder. A flat spot on the circumference of the optic mates with a machined detail in the holder. This arrangement assures that the beam exits the optical resonator at the same angle before and after cleaning or changing an optic. The nominal wedge orientation is set so that the secondary beam is located below the main beam.

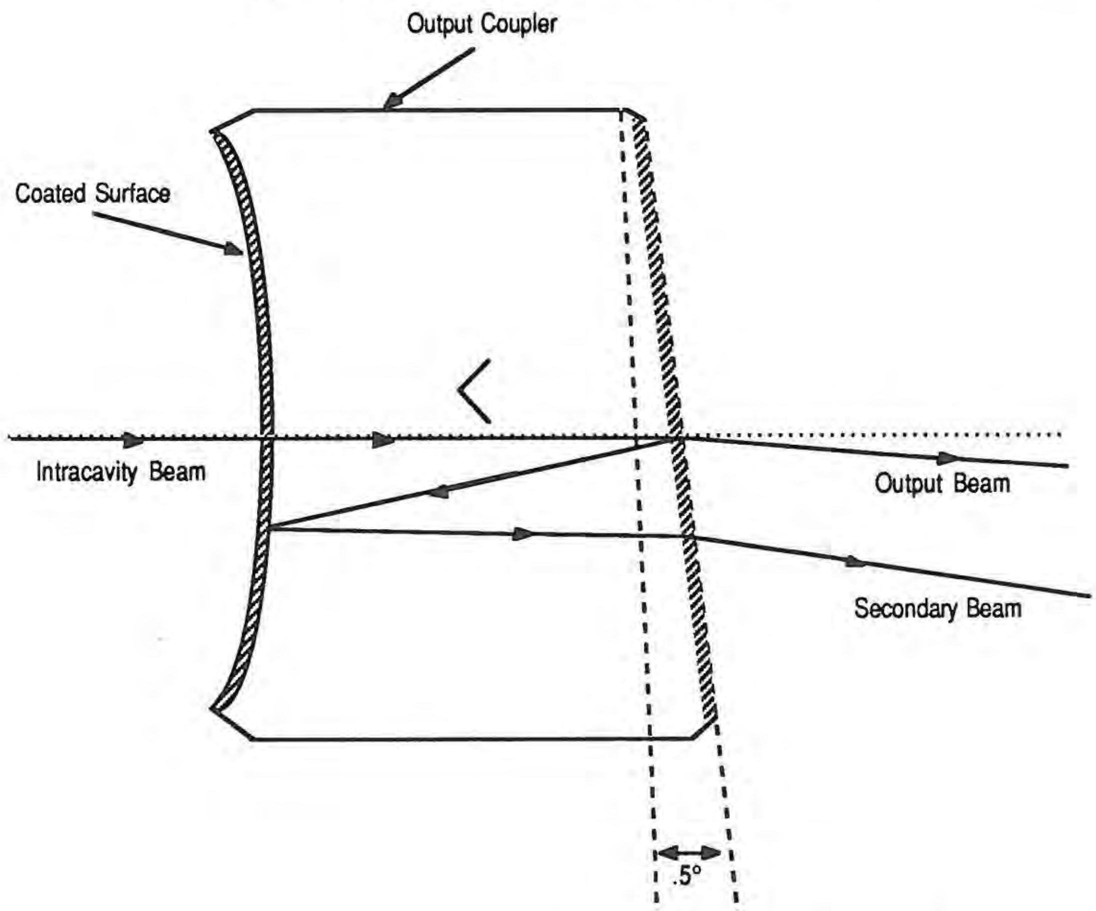


Figure 18. Output Mirror Showing Wedge Angle.

If your system does not have a keyed output mirror and holder, refer to the Output Mirror Wedge Angle Procedure in Appendix B. This procedure describes the method for preserving the wedge angle orientation when cleaning or changing an output mirror. Follow this procedure to avoid the necessity of realigning optics in the beam path outside the optical resonator.

The output mirror is located in a cylindrical holder held in place by the knurled cap at the front of the laser head.

Cleaning procedure used: Drop and Drag technique.

1 Rotate the aperture wheel to the open aperture (O) position for maximum power. Press TUNE and adjust for maximum power using the high reflector mirror tuning knobs.

2 Close the beam shutter. Unscrew the knurled cap from the output mirror holder and remove the beam pick-off assembly and the output mirror holder. The beam pick-off assembly is located inside the mirror holder and is cleaned separately (see Beam Pick-off, below).

3 Reverse the output mirror in its holder and clean the outer surface first.

4 Return the output mirror to its original orientation with the arrow pointing away from the holder. Clean the exposed inner surface of the mirror.

5 Replace the output mirror holder and beam pick-off assembly and replace the knurled cap.

6 Open the shutter. In tune mode, adjust for maximum power using the high reflector mirror tuning knobs. Rotate the aperture wheel to the desired setting.

7 Press TUNE to return to the default display and to resume PowerTrack.

BEAM PICK-OFF

The beam pick-off is located inside the output mirror holder which is held in place by the knurled cap at the front of the laser head.

Cleaning procedure used: Hemostat and Lens Paper method.

1 Rotate the aperture wheel to the open aperture (O) position for maximum power. Press TUNE and adjust for maximum power using the high reflector mirror tuning knobs.

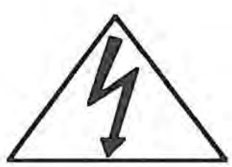
2. Close the beam shutter. Unscrew the knurled cap and remove only the beam pick-off assembly from inside the output mirror holder.
3. Clean both sides of the beam pick-off glass.
4. Replace the beam pick-off assembly and tighten the knurled cap.
5. Open the beam shutter. In tune mode, adjust for maximum power using the high reflector mirror tuning knobs. Rotate the aperture wheel to the desired setting.
6. Press TUNE to return to the default display and to resume PowerTrack.

BREWSTER WINDOW

There is a Brewster window located inside the laser head at the output mirror end of the laser tube. The window is covered by a bellows dust shield (Figure 19).

Cleaning procedure used: Hemostat and Lens Paper method.

Special care should be exercised when cleaning the Brewster window. A careless scratch on the window surface may degrade performance to such an extent that the tube must be replaced. The Brewster window is in a sealed cavity and will rarely need cleaning.



Always switch the electrical power off before cleaning the Brewster window. Extremely high voltage is present adjacent to the window when the laser is on. This voltage may cause serious shock to the operator or, if shorted to ground, may result in catastrophic damage to the tube and power supply.

1. Rotate the aperture wheel to the open aperture (O) position for maximum power. Press TUNE and adjust for maximum power using the high reflector mirror tuning knobs.
2. Turn off the laser and electrical power.
3. Remove the laser head cover.
4. Ease the dust shield bellows toward the mirror mount to expose the Brewster window. There will be a slight resistance when sliding the shield because a Teflon® O-ring seals the dust shield to the Brewster stem.
5. Clean the Brewster window.

Always wipe the window with a smooth continuous motion using light pressure. Wipe in the correct direction, from TOP to BOTTOM. Never wipe the window from bottom to top because chips can be broken from the sharp bottom edge of the window and be dragged across the Brewster surface, possibly scratching it. Make a single wipe across the surface of the window. Do not reuse the lens paper.

Figure 19. Cleaning Brewster Window Using the Hemostat and Lens Paper Method.

6 After cleaning the window, wait about 15 seconds to allow vapors to evaporate before sliding the dust shield back into place.

7 Replace the head cover.

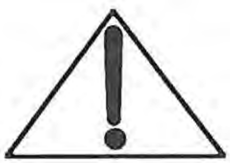
8 Restart the laser.

9 In tune mode, adjust for maximum power using the high reflector mirror tuning knobs. If power has dropped, reclean the window. Rotate the aperture wheel to the desired setting.

10 Press TUNE to return to the default display and to resume PowerTrack.

Removing and Changing The Output Mirror

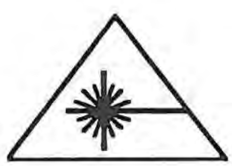
It is sometimes necessary to remove and change the output mirror, for example, when installing an accessory optic for an optional performance specification. When changing optics, always ensure that the replacement optic is clean.



Laser optics should be handled with utmost care. The slightest scratch, trace of dirt or film will severely diminish the laser's efficiency. Before cleaning optics, make sure your hands are thoroughly clean and that a clean, soft, working surface is available.

Optics and optic coatings can be easily chipped or scratched. Therefore, to prevent damage when removing or replacing mirrors, always grasp the optic by the outer edge — never touch optical surfaces.

On the side of each Coherent optic a small arrow (>) is printed. This arrow denotes the side that must point toward the laser cavity.



Safety glasses or goggles, which protect against the wavelengths used, should be worn at all times during procedures that require removal or cleaning of optics.

This procedure describes the method for changing output mirrors in order to select a different wavelength range. For example, follow this procedure to change the INNOVA 320 Series Ion Laser from full bandwidth UV (333.6 - 363.8 nm) operation to limited bandwidth UV (351.1 - 363.8 nm) operation. Refer to Table 22, Appendix A, for optics selection.

For all systems, proceed as follows:

1. Rotate the aperture wheel to the open aperture (O) position for maximum power. Press the TUNE button and align the laser for maximum power using the high reflector mirror tuning knobs. If the output power is below normal, the output mirror or Brewster window may need cleaning or the mirrors may require walking in (Care and Cleaning of Optics and Optical Alignment Procedures).
2. Stop laser action by closing the beam shutter.
3. Remove the output mirror and replace it with a cleaned mirror suitable for the desired wavelength range.
4. Open the beam shutter. If laser action occurs, maximize the laser power using the high reflector mirror tuning knobs.

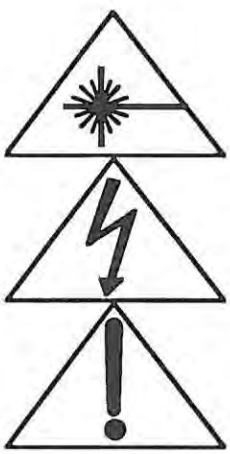
5 If lasing action does not occur with small adjustments to the vertical and horizontal high reflector mirror tuning knobs, use the Vertical Search procedure (Optical Alignment Procedures, below), to achieve lasing. Maximize power by using the high reflector mirror tuning knobs. If power output is below normal, the output mirror may need to be cleaned again or walked-in (Care and Cleaning of Optics and Optical Alignment Procedures).

6 Adjust the aperture wheel to the desired setting.

7 Press TUNE to return to the default display (also resumes PowerTrack).

Optical Alignment Procedures

The optical alignment procedures which follow expose the operator to hazards of laser emission and electric shock. To minimize these hazards, follow these guidelines:



Wear safely glasses or goggles which protect against the wavelengths used at all times during optical alignment procedures.

Circuits in the laser head operate at high voltages. HIGH VOLTAGES CAN BE LETHAL. Use EXTREME CAUTION whenever it is necessary to operate the laser with the head cover removed.

Use the TUNE button to disengage PowerTrack when carrying out any optical alignment procedure.

Aperture Alignment Procedure

The aperture may need aligning if the tube position has changed or the mirrors have been walked-in. To check alignment, rotate the aperture from the open aperture position to smaller holes (higher numbers to lower numbers) while observing output power. The output power should decrease gradually as smaller and smaller aperture holes are used.

If the aperture is misaligned, output power will drop dramatically as smaller aperture holes are chosen and at some point the aperture may completely occlude the output beam and lasing will cease.

The aperture uses a two-point positioning system (Figure 20). The aperture assembly is spring loaded against two

screws located on either side of the aperture assembly. The aperture position may be changed by adjusting the two screws with a hex key.

Align the aperture as follows:

1 Shut down the system and remove the laser head cover so the aperture can be accessed.

2 Set the aperture to the open aperture position.

3 If you suspect that the aperture is grossly misaligned, remove the output mirror holder. Look into the laser through the aperture. Center the hole of the aperture disk using a 3/32 in. hex key. Re-install the output mirror.

Never look into the plasma tube unless the laser is turned off. Even when not lasing the UV discharge of the tube can cause eye damage.

4 Install the interlock defeats and restart the system. Press TUNE to center PowerTrack and engage Current Regulation Mode. Set to full current.

5 Walk-in the mirrors using the walk-in procedure (Mirror Alignment Optimization, below).

6 To ensure that the beam is aligned within the bore as well as within the aperture, perform Step 5 until no further increase in power is observed. Though undesirable, the aperture can be aligned to the beam even when the beam is misaligned to the tube.

7 Decrease the aperture setting to 10 and carefully adjust the aperture tuning screws to maximize output power. For optimum performance, align for maximum power at the particular aperture setting most frequently used. The aperture may also be aligned by over-aperturing the beam and adjusting the aperture so that the diffraction rings (viewed by expanding the beam on the ceiling) are symmetrical.

8 Check for gradual power decrease as the aperture wheel is rotated from the largest hole to the smallest.

9 After aperture alignment, shut down the laser, remove the interlock defeats and reinstall the head cover.

10 Restart the laser and rotate aperture wheel to the desired setting.

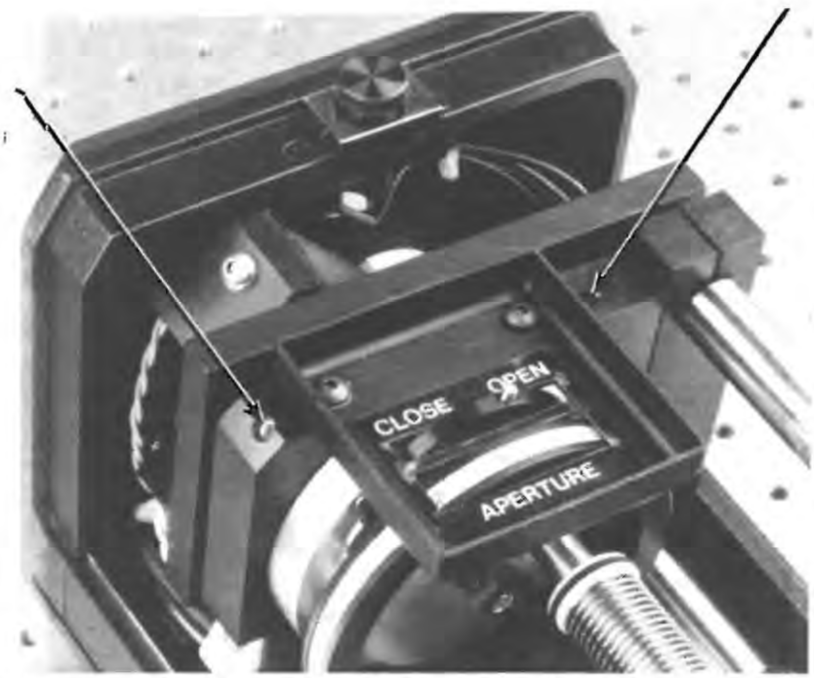


Figure 20. Aperture, Showing Adjustment Screws.

MIRROR ALIGNMENT PROCEDURES

There are three mirror alignment procedures, each used to remedy a different type of mirror misalignment:

1. If lasing does not occur, use the Vertical Search procedure to align the high reflector mirror.
2. Use the Coarse Mirror Alignment procedure to align the output and high reflector mirrors with each other only if the Vertical Search procedure will not initiate any laser action.
3. Use the Mirror Alignment Optimization procedure (walk-in) to optimize the alignment of both the output mirror and the high reflector mirror to the tube. This procedure is necessary when output power is below normal and/or the laser mode is nonsymmetric even after all optics have been properly cleaned.

VERTICAL SEARCH PROCEDURE

This procedure is used whenever the high reflector mirror is misaligned to such an extent that the laser does not lase. Assuming that the output mirror is in alignment with the plasma tube, this procedure will rapidly and systematically scan the high reflector mirror through a grid of possible positions until the mirrors are aligned.

When using this procedure in UV, place a white card in the beam path and watch for a flash of fluorescence on the card.

1 Switch the laser on and set at full current in current regulation. Make sure the intracavity shutter is in the open position.

2 Rotate the aperture wheel to the open aperture (O) position for maximum power. Press the TUNE button.

3 Turn the rear vertical tuning knob counterclockwise several turns to tip the mirror downward.

4 Pull the high reflector mirror mount toward the rear of the head and then slowly let it return to its original position. This is known as rocking the high reflector mirror mount (Figure 21). If no lasing flash is observed, rotate the horizontal tuning knob very slowly in one direction while rocking the mount rapidly. Watch very carefully for the lasing flash as you scan the high reflector mirror.

If you do not observe a flash after rotating the horizontal tuning knob three full turns in one direction, reverse the turning direction of the horizontal tuning knob and repeat the scanning process until the laser flashes — be patient. It is not unusual, especially in UV, to scan the horizontal tuning knob back and forth several times before flash is observed.

5 When you observe a flash, rotate the vertical tuning knob clockwise until lasing is continuous.

6 Optimize the power by tuning both horizontal and vertical tuning knobs, one at a time.

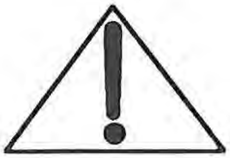
7 Adjust the aperture wheel to the desired setting.

8 Press TUNE to return to the default display.

Figure 21. Rocking the High Reflector Mirror Mount.

COARSE MIRROR ALIGNMENT

This procedure is used when lasing cannot be achieved by using the Vertical Search procedure and when alignment of the output mirror adjustment plate has been changed or is not known.



Only use this procedure if it is impossible to achieve lasing by using the Vertical Search procedure.

1 Shut down the laser. Remove the laser head cover and defeat the head interlocks (Figure 22).

2 Remove the beam block from the rear mirror plate by unscrewing the three retaining screws (refer to Figure 12 for location of beam block).

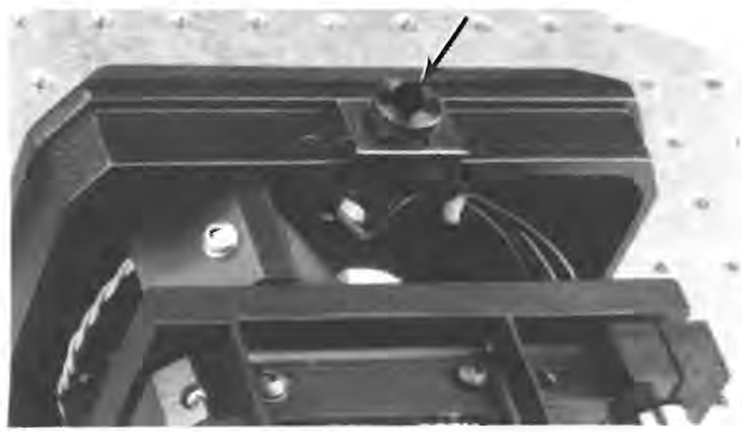


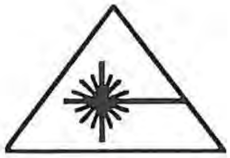
Figure 22. Interlock Defeat in Place on End Bezel

3 Slide the dust shield bellows away from the tube to completely expose the Brewster window. Open the shutter. Rotate the aperture wheel to the largest opening (O). Restart the tube. Select current regulation and increase the tube to maximum current.

4 Deactivate PowerTrack. Press the TUNE button to center the PowerTrack actuators.

5 For INNOVA 320 systems which operate in UV, remove and replace the output mirror with the visible, highly reflective mirror (P/N 0903-004-00) supplied in the maintenance kit.

6 Make a 1 mm hole near the edge of a white card (an index or business card).



Lasing action may start at any time during the following adjustment sequence. Place a beam stop in front of the laser head output aperture to prevent exposure or damage to sensitive equipment in the beam path. Also place a beam stop at the rear of the laser head. The aperture exposed by removing the beam block from the rear mirror plate will transmit plasma and laser light because the mirror which is sealed onto the laser tube is less than 100% reflective. Do not look at the discharge inside the tube even when there is no laser action. The UV discharge in the tube can cause eye damage.

7 Place the card against the Brewster window stem so that the hole in the card is centered on the violet plasma glow from the tube as viewed from the front of the laser (Figures 23 and 24).

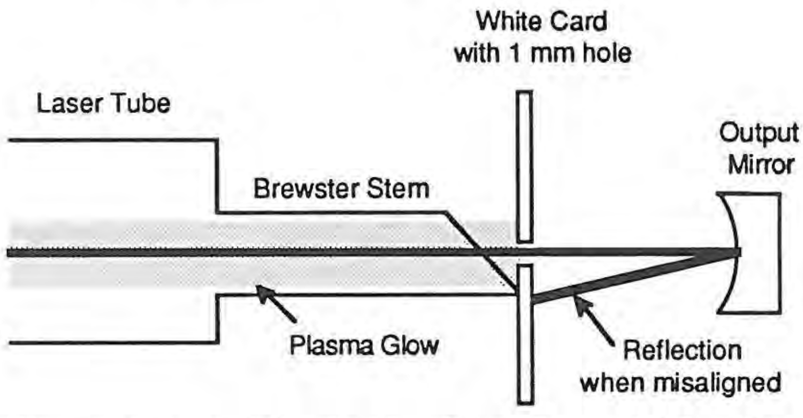


Figure 23. A White Card with a 1 mm Hole Placed Against the Front Brewster Stem of the Tube.

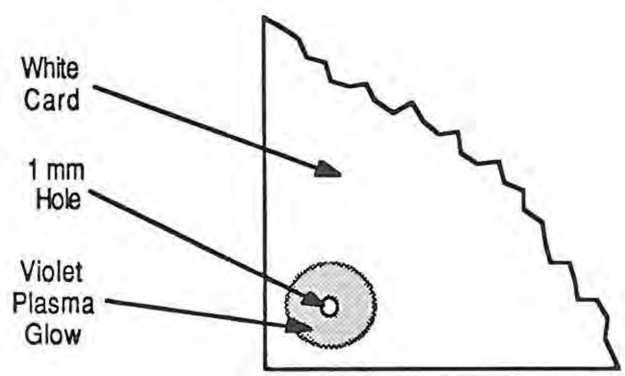


Figure 24. Centering the Hole in the Plasma Glow (tube is on other side of card).

8 Use a 5/32 in. Allen wrench to adjust the output mirror horizontal and vertical tuning screws (refer to

Figure 25 for location of access holes in the front head bezel for these controls) while observing the plasma glow from the front side of the card. You should see a small spot reflected from the output mirror which moves as you make adjustments (Figure 26).

If you do not see the reflected spot, check that the shutter is open, the aperture is fully open, and the output mirror is properly installed. In the case of UV systems, check that the output mirror has been exchanged for the visible, highly reflective mirror.

Figure 25. Front View of the Laser Head Showing the Access Holes to the Output Mirror Vertical (upper left) and Horizontal (lower right) Tuning Screws.

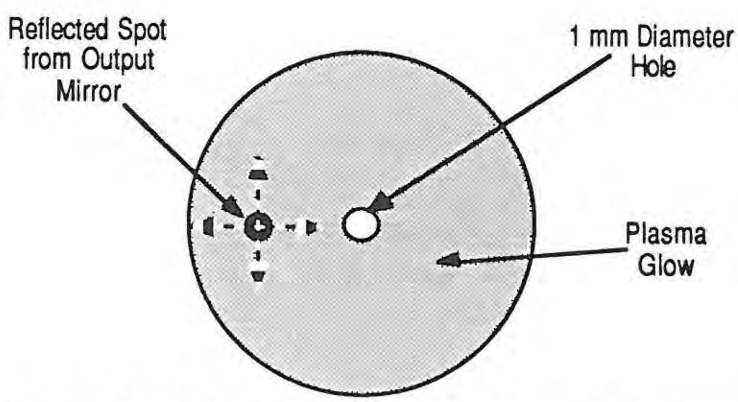


Figure 26. Expanded View of Figure 24, Showing Reflected Spot on the Plasma Glow.

9 Use the Allen wrench to adjust the horizontal and/or vertical tuning screws until the reflected spot from the output mirror is centered on the hole in the card.

10 Remove the card from the laser head.

11 Place a large white card at a distance of 50 to 100 cm from the rear of the laser head so that the plasma glow transmitted from the rear of the head is centered on the card. In this plasma glow, you should now see a weak reflected spot from the output mirror. Open and close the shutter several times to check for this reflected spot. It may be necessary to dim the ambient light or otherwise shade the plasma glow in order to see the spot.

If you cannot see the spot, repeat steps 7 through 11 making sure that the front mirror reflection is centered on the hole in the card.

12 If the reflected spot is visible but is not perfectly centered in the plasma glow from the rear mirror aperture, carefully adjust the output mirror horizontal and/or vertical tuning screws until the spot is centered (Figure 27).

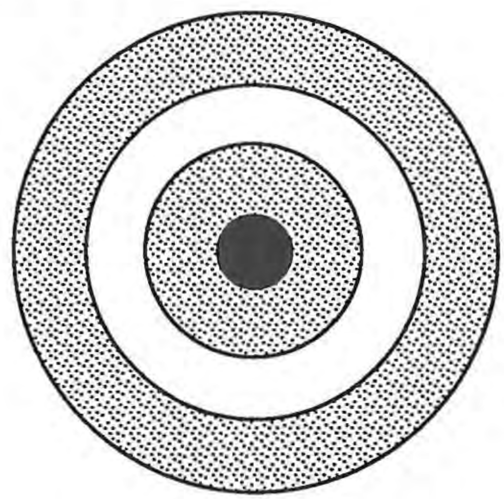


Figure 27. Reflected Spot Centered in Plasma Glow.

13 Shut down the laser system.

14 Slide the dust shield bellows into place on the Brewster window stem.

15 Remove the interlock defeats and replace the laser head cover.

16 If the laser system operates in the UV (INNOVA 320 Series), replace the visible, highly reflective mirror installed in the output mirror mount with the appropriate UV output mirror.

17 Mount the beam block on the rear mirror plate with the three retaining screws.

18 Restart the laser system. Proceed to the Vertical Search procedure to achieve lasing, then to Mirror Alignment Optimization procedure to walk-in the mirrors.

Mirror Alignment Optimization

When lasing action occurs, it indicates that the mirrors are parallel, but does not guarantee that they are optically aligned to the bore of the tube. Figure 28 shows, in exaggerated form, an operating laser with its output mirror improperly aligned. Here the optical and tube axes are not colinear. Maximum power, obtainable by resonator alignment only, is achieved by adjusting the two mirrors to make these axes coincide. This alignment is done by a walk-in procedure described below.

Walk-In Procedure

To align the mirrors to the bore, or to walk-in the mirrors, proceed as follows:

1 Set the laser to maximum current in Current Regulation Mode. Rotate the aperture wheel to the open aperture (O) position for maximum power. Press the TUNE button to disengage and center PowerTrack and display the system power meter. Maximize the output power using the high reflector mirror tuning knobs.

Always perform this alignment procedure with the laser in TUNE mode. This will ensure that the PowerTrack actuators are centered.

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2 Note the initial power. Gradually turn one of the output mirror tuning screws with a 5/32 in. Allen wrench until the power drops to one-half.

3 Turn the high reflector mirror tuning knob of the same axis until the power is again maximized. Adjust to maximum power using both high reflector tuning knobs.

4 If the maximum power is now higher than before, turn the output mirror tuning screw farther in the same direction in the same axis, then repeat step 3.

5 If the power has decreased, turn the same output mirror tuning screw in the opposite direction until the power drops one-half, then repeat step 3.

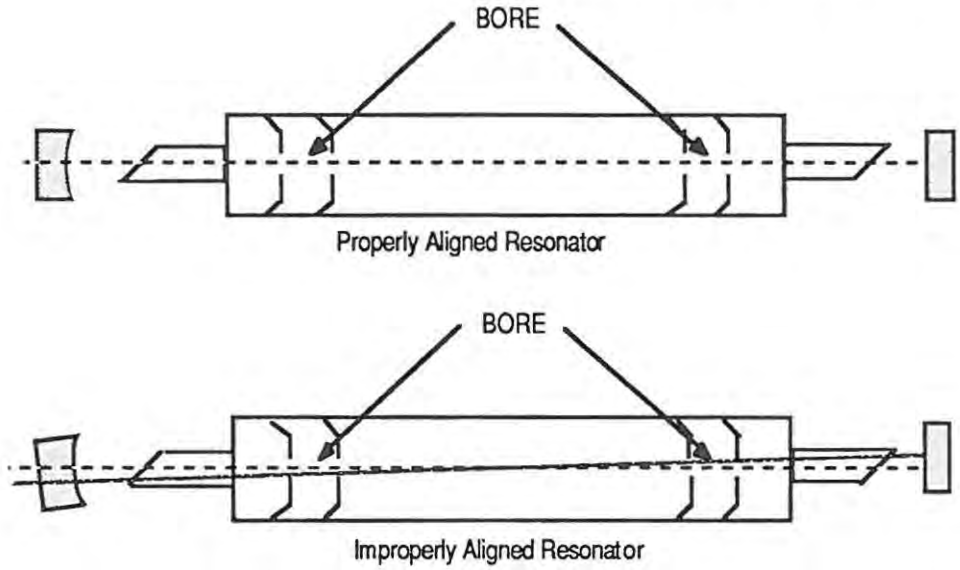


Figure 28. Difference Between Properly and Improperly Aligned Resonator.

6 Repeat steps 3, 4 and 5 decreasing the amount of adjustment to the output mirror tuning screw each time the direction is changed until the power is maximized.

7 When the power is maximized, turn the other output screw and repeat the trial-and-error adjustments (steps 2-6) until the laser is at its maximum power.

8 When both output mirror tuning screws can no longer be tuned to produce more power, the mirrors are aligned.

9 Adjust the aperture wheel to the desired setting.

10 Press TUNE to return to the default display.

INNOVA® 310/320 SERIES ION LASER

OPERATOR'S MANUAL

CHAPTER SEVEN
THEORY OF OPERATION

COHERENT®

THE NOBLE GAS ION LASERS

The INNOVA 310/320 Series Ion Laser belongs to a class of lasers known as the noble gas ion lasers — so called because they incorporate a tube of ionized gas as their gain medium. Argon and krypton ion lasers have become one of the most important sources of coherent radiation in the visible and near-visible spectrum. Extensive research and engineering have been devoted to making ion lasers rugged and reliable.

Laser action requires a light amplifier and an optical cavity that stores light energy. Laser light will be produced when the amplifier provides sufficient gain to balance the loss of the optical cavity.

GAIN — THE ION LASER PLASMA

Ion lasers derive their gain from a plasma tube, a sealed cylinder containing gas at low pressure. An electric discharge is passed through this gas producing a plasma in which gas particles become ionized — hence the term ion laser.

Figure 29 shows a simple set of quantum energy levels that illustrate the principles on which ion lasers operate. The electrons in the plasma discharge strike the gas particles, ionizing them and also promoting them into highly excited energy levels from which they can emit light as they fall to lower energy states. The ions eventually distribute themselves in a complex fashion among the various quantum levels. Under carefully chosen conditions of current, voltage and gas pressure, a situation similar to Figure 29 will be attained: the number of ions in some level (B) will exceed the number in a lower energy level (A). This situation is termed a population inversion and is a necessary condition for laser gain. Stimulated emission by ions in state B will produce photons of light, the ions falling into state A in the process. Laser plasma tubes are designed to provide the precisely controlled conditions under which population inversions can be sustained. The greater the population difference between states A and B, the greater will be the laser gain.

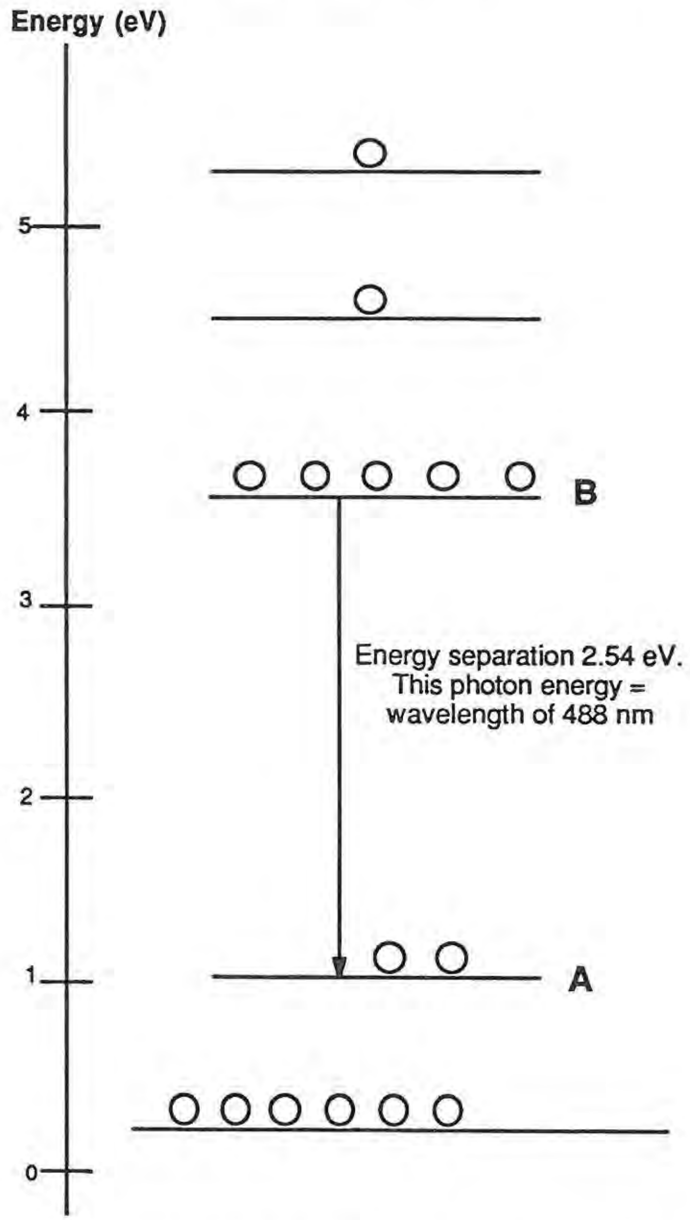
The wavelength (λ) at which this gain is seen is determined by the energy separation between A and B. This is expressed by the DeBroglie formula:

$$E=hc/\lambda$$

where E is the energy separation between A and B, h is Planck's constant (4.1359×10^{-15} eV sec) and c is the speed of light (2.9979×10^{8} m/sec). In the figure, levels A and B are separated by 2.54 eV, corresponding to a wavelength of 488.0 nm.

In Figure 29 there is only one pair of levels with a population inversion, but this figure is greatly simplified compared to the actual quantum level structure of an argon or krypton ion. Argon, for instance, may have as many as one hundred

quantum level pairs that simultaneously exhibit population inversions. For each quantum level pair there is a corresponding wavelength where the plasma exhibits gain. Each of these wavelengths is called a laser line. The presence of numerous laser lines throughout the visible and near-visible spectrum is one of the virtues of ion lasers. The specification tables in Chapter One list the lines that are present in the INNOVA 310/320 Series Ion Lasers.



The horizontal lines represent quantum states, the number of circles on each line represents the number of ions in each state. The population in B exceeds the population in A, therefore laser gain can exist at 488 nm.[1]

Figure 29. Ar+ Energy Level Schematic.

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[1] This figure is for illustrative purposes only and does not correspond to the actual energy levels of Ar+.

Only a few gases have the right quantum mechanical properties to be used in ion lasers. Argon and krypton — two of the noble gases — have become widely used because of their relatively high gain, good efficiency and large number of lines at useful wavelengths. The noble gases also have the advantage of being chemically inert, which simplifies many aspects of plasma tube design.

Feedback and Loss — The Optical Cavity

The optical cavity of an ion laser stores the light energy produced by stimulated emission in the plasma tube. In simple terms the cavity looks like Figure 30. At one end is the high reflector mirror, a mirror with a reflectivity of nearly 100%. At the other end is an output mirror that reflects somewhat less than 100% of the intracavity power. The rest of the light passes through the output mirror to form the output beam. Transmission of light by the output mirror constitutes a loss of energy from the cavity. Laser action will occur only when there is sufficient gain in the tube to overcome this loss.

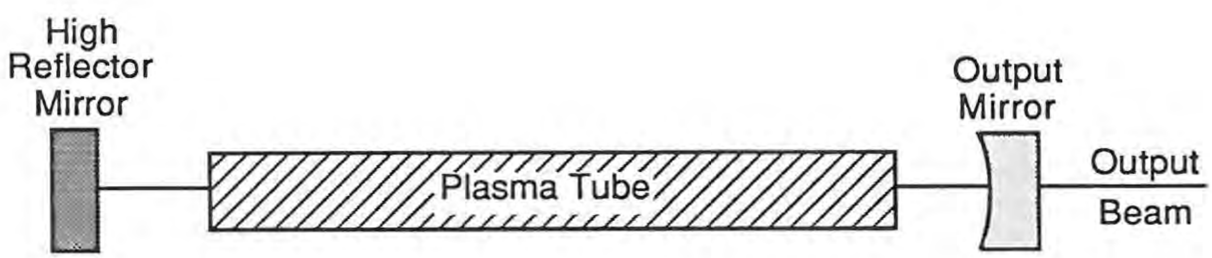

Figure 30. Multiline Configuration.

The cavity mirrors are made by depositing dielectric coatings on a polished surface of quartz or glass. The reflection and transmission properties of these mirrors are controlled by this coating process.

Optical Cavity Configuration

In multiline operation (Figure 30), the laser operates in several lines simultaneously, usually a group of lines that lie close together in wavelength. The performance of the laser in this configuration is determined by the wavelength response of the dielectric coatings on the output mirror and high reflector mirror. All of the laser lines that have sufficient gain to overcome the cavity losses will oscillate in this cavity.

Output Beam Size

Laser light does not focus to a point but to a spot of finite diameter at a position called the beam waist. Moving away from the waist, the beam will gradually increase in size at a rate given by its divergence. [1]

The optics of the laser cavity determine the waist position, beam diameter and divergence of the output beam. For example, the standard INNOVA 318 Series Argon Ion Laser cavity consists of a flat high reflector mirror and a 10 m radius of curvature output mirror. This simple cavity produces a waist at the high reflector mirror and a divergent intracavity beam at the reflecting surface of the output mirror optic, which acts as a slight negative lens in the output beam (it consists of a concave reflecting surface and a flat exit surface). This arrangement causes the output beam to behave as though it had a waist behind the high reflector mirror. Refer to Table 5 for the imaginary or virtual beam waist and beam divergence specifications. Use these values when estimating the behavior of the INNOVA 310/320 Series beam as it propagates through optical elements such as lenses or mirrors.

Polarization

The output end of the INNOVA 310/320 Series plasma tube is sealed with a piece of crystalline quartz called a window which admits the intracavity beam into the plasma discharge region. This window is carefully oriented so that the beam intersects the window surface at Brewster's angle. At this special angle, light whose polarization vector is parallel to the plain of incidence of the window surface will experience zero surface reflection loss.

The opposite polarization will suffer sufficient loss that it will not be sustained within the laser cavity. The Brewster window thus serves two functions: it keeps the cavity losses as low as possible and also provides a vertically polarized output beam.

Transverse Modes

The electromagnetic energy stored in the laser cavity is distributed in certain mathematically defined patterns called the transverse modes of the cavity. In the simplest of these patterns, the maximum light intensity is found at the center of the beam. As the distance from the center increases, the intensity falls off smoothly and uniformly. This pattern is the so-called Gaussian or TEM_{00} mode. More complex patterns also exist and are collectively termed higher-order modes. Some examples and their designations are illustrated in Figure 31. Note that in Figure 31 the printed areas (dark) represent laser light, the unprinted areas represent the

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[1] For a full treatment of this subject, see: *Lasers*, Siegman, Anthony E. Mill Valley, CA: University Science Books, 1986.

absence of laser light. The typical mode patterns exhibit the cylindrical symmetry of the laser cavity.

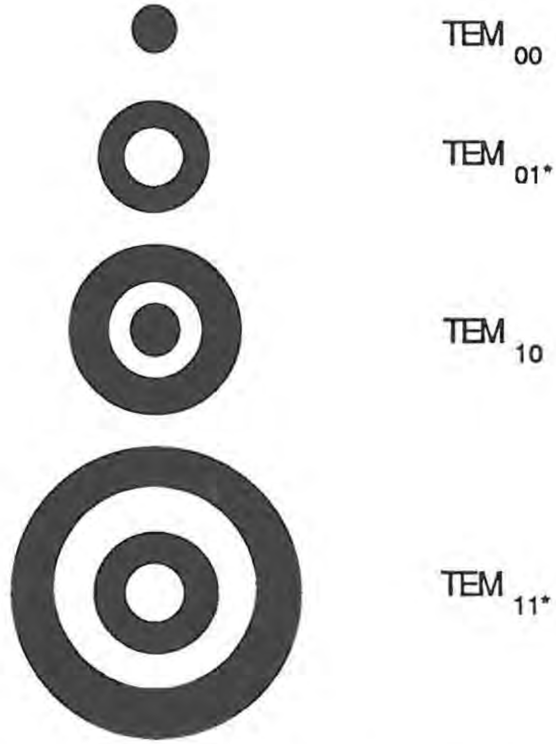


Figure 31. Transverse Electromagnetic Beam Profiles.

The TEM_{00} mode is of special interest, since it has the smallest diameter of any of the transverse modes and will propagate through optical systems (lenses and mirrors) in close agreement with the formulas of Gaussian optics. For applications that require extremely tight focusing of the output laser beam, TEM_{00} mode operation is essential. This mode is achieved in the INNOVA 310/320 Series Ion Laser by means of the adjustable intracavity aperture. This aperture discriminates against higher-order modes by exploiting the relatively small diameter of the TEM_{00} mode. Higher-order modes experience a large loss at the surface of a small aperture and are effectively suppressed.

The aperture in the INNOVA 310/320 Series Ion Laser comprises a set of holes of different sizes mounted on a rotating wheel. The optimum aperture setting is typically selected by systematically choosing smaller holes while observing the shape of the output beam.

Since TEM_{00} operation is attained by introducing a loss into the cavity, it necessarily involves a reduction in output power. Maximum output power is achieved with the aperture fully open and the laser producing a multimode beam.

Each individual laser line may require a different aperture setting in order to obtain TEM_{00} mode oscillation. In general, the aperture setting will depend on both line gain and wavelength, with high gain and short wavelength lines requiring smaller aperture sizes. In multiline visible systems (the INNOVA 318, for example), the large difference in gain among the lines, and the consequent difference in aperture sizes needed to force TEM_{00} operation, makes it difficult to define a multiline TEM_{00} mode in a meaningful way. For example, the aperture required to obtain a TEM_{00} mode for the high gain, short wavelength line at 488.0 nm would introduce uselessly large diffraction losses in lower gain lines such as 514.5 nm. These lines would then suffer severe power decreases which would show up as a large, overall power decrease in multiline output power.

For this reason, the power specification for multiline visible operation is given at open aperture and for a TEM_{01}^* mode. On the other hand, the more uniform gain and limited wavelength range of the UV lines makes it possible to define a multiline UV TEM_{00} power specification without introducing an excessive loss in any UV line.

Care must be taken when observing the laser mode since a small intracavity aperture introduces a diffraction pattern onto the output laser beam. This pattern appears as a set of concentric dark rings on the beam profile. The rings disappear at a large distance (>5 m) from the laser head. At certain distances — determined by the diameter of the aperture and the wavelength of the light — the diffraction pattern will have an intensity minimum on the beam axis causing the center of the beam to appear dark. This condition is not indicative of a higher-order laser mode, which would maintain its dark center at all distances from the laser.

THE MAGNET

The laser tube in the INNOVA 310/320 Series Ion Laser is enclosed in an axial electromagnet which produces a magnetic field inside the plasma tube. This field exerts a force on the ions in the plasma discharge, tending to confine them to the center of the tube and thereby increasing the laser gain.

At the same time, however, the magnetic field introduces an energy splitting of the quantum levels that produce the laser gain. This Zeeman effect is a major contribution to the gain bandwidth of ion lasers.

The magnet has two internal windings, providing two different magnetic field strengths. The standard low field winding gives optimum performance for the relatively high-gain visible laser lines, while the auxiliary or high field winding is used to give higher output powers for the low-gain UV lines.

The Plasma Tube

The IonPure™ plasma tube in the INNOVA 310/320 Series Ion Laser is the result of years of technological evolution and represents the state-of-the-art in ion tube design. An ion laser tube must meet several demanding requirements: it must control and confine an electrical discharge whose current density is on the order of 700 amperes per square centimeter; it must efficiently conduct heat from the tube bore to the surrounding cooling water; it must be vacuum tight and have electrically insulating walls; and it must maintain a uniform gas pressure at the level which gives the highest laser gain. These design criteria must be met in a manner consistent with component reliability and long operating life.

At the center of the tube is an open region called the tube bore. At one end of the bore is the cathode where electrons are emitted. A series of metal disks extends throughout the length of the tube confining the plasma to the center of the bore. The electron path terminates at the anode.

The disks are constructed of tungsten, a material with two favorable properties: a high resistance to melting under the extreme heat load produced in the plasma and a high resistance to sputtering under the impact of ionized gas particles.

The disks are surrounded by a vacuum sealed ceramic envelope which efficiently conducts the heat built up in the disks. The outside of the ceramic is cooled by direct contact with a flow of cooling water.

This metal/ceramic construction ensures mechanical strength and ruggedness. The vacuum envelope is formed of a single seamless cylinder of alumina ceramic, chosen for its combination of mechanical strength, electrical insulation and thermal conductivity.

All ion laser tubes suffer a slow loss of gas pressure during operation and must include a means of maintaining the optimum pressure over the lifetime of the tube. On the INNOVA 310/320 Series Ion Laser, this task is accomplished by means of an auxiliary gas reservoir and an electronically activated fill system. When circuitry in the power supply

senses a drop in gas pressure, it automatically activates the fill mechanism to replenish the gas inside the laser tube. This Autofill system ensures that the tube pressure will be maintained without attention from the laser operator.

THE RESONATOR

Like any laser, the performance of the INNOVA 310/320 Series Ion Laser is extremely dependent on optical alignment. To obtain the maximum output power from the laser, two conditions must be met:

1. The high reflector mirror and output mirror must be precisely aligned to each other—should either optic be tilted by as little as ten microradians from its optimum orientation, an easily detectable loss of power will occur.
2. The plasma tube must be precisely centered on the axis defined by the two optics.

This sensitivity to alignment places stringent demands on the mechanical components that secure the optics and plasma tube during operation. These components, collectively termed the resonator, can be affected by thermal changes and vibration. The resonator design must take into account not only the demands of optical alignment, but also the fact that the laser head is an active environment containing a 10 kW tube discharge and a 8.5 liter (2.2 gallons) per minute flow of coolant.

The resonator structure of the INNOVA 310/320 Series Ion Laser uses Super Invar, a material that combines excellent mechanical rigidity with a low coefficient of thermal expansion. Three rods of Super Invar form the framework to which the optical mounts are attached. While the low coefficient of expansion helps to maintain the cavity length, flexure mountings provide the greatest possible vibration isolation for the laser mirrors. The resonator frame is mounted to the laser head by flexure mounts that allow thermal expansion of the magnet and resonator without affecting the optical alignment of the cavity. The magnet is secured to the baseplate by a fixed mount at one end and by a flexure mount at the other. This design permits thermal expansion of the magnet without exerting forces on the baseplate or resonator structure.

When the laser is first started up, components in the laser head enclosure experience thermal changes. Until the entire head reaches a steady state, changes in alignment may occur that noticeably affect output power and beam direction. The rate at which steady state is approached depends on

many environmental factors, but small thermal changes can be detected as long as two to four hours after the laser is initially started up. For most applications a half-hour warm-up is sufficient; for extremely critical performance, a longer warm-up may be necessary.

During operation, the laser alignment will be affected by changes in the cooling water temperature and flow rate, the ambient air temperature and also by changes in the laser operating current.

PowerTrack

PowerTrack provides automatic, servo-controlled alignment for the output mirror, continually holding the output mirror in the position that provides optimum alignment. With the PowerTrack servo engaged, the laser will produce optimum power even during the warm-up period. An additional benefit of the improved resonator alignment is a typical reduction in output amplitude noise.

A pair of electromagnetic actuators control the tilt of the output mirror about two axes. The actuators are tilted back and forth (dithered) at a frequency of 30 Hz. The size of the dither is chosen to be extremely small, introducing a modulation of the laser output power that is much less than the intrinsic amplitude noise of the laser.

While the frequency spectrum of the intrinsic noise is quite broad, the PowerTrack modulation occurs at the single frequency of 30 Hz with a known phase angle. Therefore, the PowerTrack information can be effectively extracted from the noise by sampling the laser output beam (using the same laser head photodetector employed in the light regulation circuit) and passing the resulting signal through a 30 Hz filter. The filtered output is then processed by precision analog circuitry to generate the PowerTrack error signals, which in turn are fed to the actuators to maintain optimum mirror alignment. Using the dither-and-track detection method, PowerTrack achieves high sensitivity without introducing unwanted beam noise. By the nature of the dither-and-track method, PowerTrack operates only when the laser is lasing.

The Intracavity Space

During the operation of any high-powered ion laser, photochemical conversion of oxygen to ozone can take place in the beam path. Gradual build-up of ozone within the cavity

will cause a serious degradation in laser power. Degradation is avoided in the INNOVA 310/320 Series Ion Laser by surrounding the intracavity beam path between the Brewster window and the output mirror with a sealed beam enclosure tube. This tube incorporates a catalyst that decomposes ozone. This catalytic system eliminates the need for cumbersome air purges and provides a clean environment for the laser optics.

THE POWER SUPPLY

The main function of the INNOVA 310/320 Series Ion Laser power supply is to provide a properly conditioned flow of current through the plasma tube. The design of the power supply is therefore dictated by the electrical characteristics of the tube.

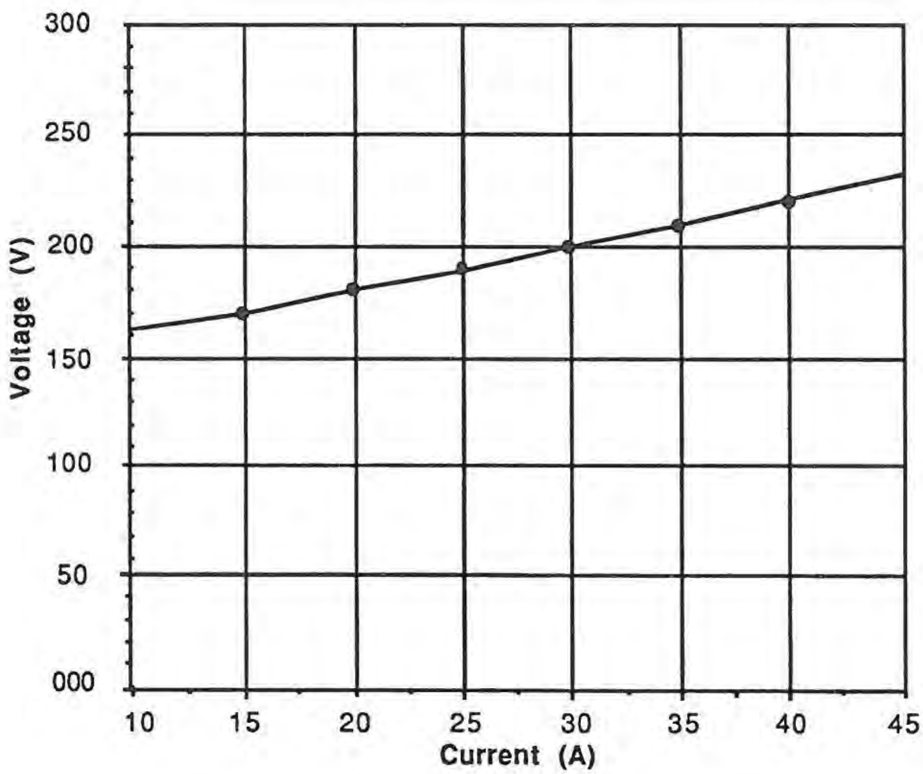


Figure 32. Typical V-I Curve.

When the plasma tube is ionized, it offers a resistance to current flow. The associated voltage drop is termed the tube voltage, which is a complex function of the amount of current flowing through the plasma discharge and the pressure of the gas inside the tube. The resistance of the tube does not obey Ohm's law and must therefore be characterized in terms of a dynamic voltage/current relationship known as

the V-I curve, a typical example of which is shown in Figure 32. Under the operating conditions of the INNOVA 310/320 Series Ion Laser, this curve is nearly linear, but with a slope considerably less than the ratio V/I at any point. For this reason, a stable laser output is more readily achieved by current regulation than voltage regulation of the tube drive circuit.

The entire V-I curve shifts downward as the gas pressure inside the tube drops. This phenomenon is the basis for the Autofill system, which activates the gas fill mechanism when it detects a low tube voltage. This downward shift of the V-I curve with gas pressure is most pronounced at high tube currents and therefore the most accurate pressure readings are obtained at high current.

The V-I curve bends sharply upward at very low current and at zero current the tube exhibits a large resistance to current flow. To start the tube, the cathode filament is switched on and brought to its proper operating temperature. This requires approximately 30 seconds and is called the start delay. A starter circuit then applies a brief pulse of high voltage across the tube to achieve ionization. The current regulation circuitry takes control of tube operation thereafter.

A simplified diagram of the power supply is shown in Figure 33. Incoming three-phase power is rectified and passed through an LC filter, generating positive (B+) and negative (B-) DC voltage. The magnet is connected directly across these points. The tube and the current regulator are in series from B+ to B- and therefore the voltage drops across these two circuit elements must sum to the potential difference between B+ and B-. At low tube currents, the tube voltage is relatively low, and the current regulator voltage drop is relatively high.

Current regulation is provided by a linear passbank, represented on the simplified schematic as a single pass transistor. A current sensing resistor provides a low-voltage signal proportional to the current. This signal is fed to a comparator which drives the base of the pass transistors. The reference for the comparator is an adjustable voltage set by the microprocessor, thus the supply maintains a constant current flow through the tube. This mode is called Current Regulation Mode. Alternatively, a photocell is used to sample the laser output power which is compared to a set point. The error signal is used to adjust the reference level on the current regulator, providing feedback stabilization of the laser output power. This mode is called Light Regulation Mode. Both Current and Light Regulation Mode are available under the CPU control on the INNOVA 310/320 Series Ion Laser.

In addition to the main functions described here, the power supply CPU also monitors a set of safety interlocks and provides a readout of faults, system status, laser power and tube current.

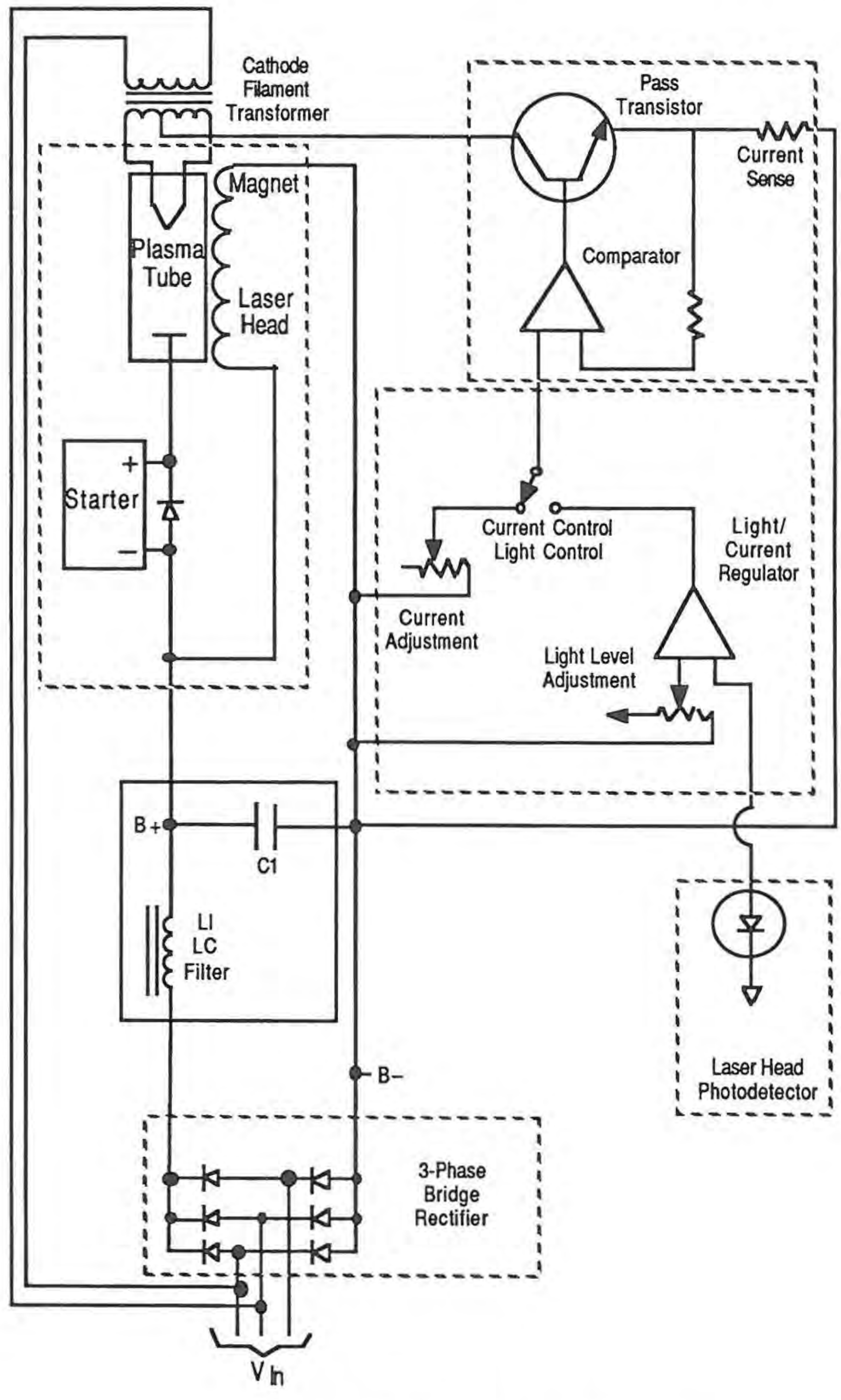


Figure 33. Simplified Laser Diagram.

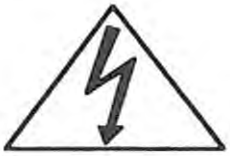
INNOVA® 310/320 SERIES ION LASER

OPERATOR'S MANUAL

CHAPTER EIGHT MAINTENANCE AND TROUBLESHOOTING

COHERENT®

PREVENTIVE MAINTENANCE



Circuits in the laser head and power supply operate at high voltages. HIGH VOLTAGES CAN BE LETHAL. Use EXTREME CAUTION whenever operation without the head cover or the power supply cover is required. If operation of the laser is not required for maintenance procedures, disconnect the main power before removing covers.

If the laser is powered up with condensation on the passbank, catastrophic damage could result. Condensation occurs if the temperature of the passbank drops below the ambient dew point.

LASER HEAD COVER INTERLOCKS

The laser head is fitted with two interlocks, one on each end bezel, that switch the laser off if the head cover is removed. Each interlock consists of two pins which must be connected to the interlock defeats in order to operate the laser with the head cover removed.

If a cover interlock fault occurs, the system will shut down and the LCD on the remote control module will read **Head Interlock**. This fault must be corrected and cleared before the laser can be restarted.

ELECTRICAL INSPECTION

Check electrical connections regularly to ensure that good contact is maintained and that insulation, especially on the cathode and anode leads, is in good condition. Look for discoloration of wire insulation, a sign that excessive heat is building up in the wire.

OPTICAL INSPECTION

If optical surfaces are cleaned too often, the possibility of scratching mirror surfaces is increased. The useful life of optics may also be shortened. Keep the laser cavity sealed to prevent contamination of cavity optics and always store extra optics in the sealed containers provided.

In the event of marked power loss, the optical surfaces should be checked to ensure they are free from surface contaminants and damage. Examine the optic in different lights for films, streaks, or dust particles. If the optic is dirty, clean the optic as described in Chapter Six, Optics and Alignment.

Water System Inspection

Water Hose Inspection

Periodically check water hoses and water connections for wear and leaks. Replace worn hoses to avoid serious and potentially hazardous flooding of the laser head and power supply interiors or laboratory work space.

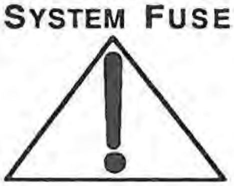
Water Filter Replacement

The quality of local water determines the frequency of water filter replacement; experience will be the best guide. If the water contains many particulates, the filter may need to be changed often. If the filter clogs, the laser will shut down due to lack of water flow. It is best to replace the filter before shut-down occurs.

If a Coherent water filter assembly is in use, replace the filter with P/N 2603-0016.

Corrective Maintenance

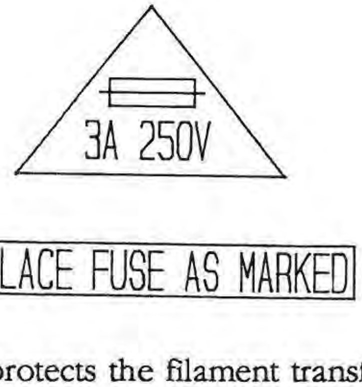
Checking the System Fuse



Before checking the system fuse, disconnect the main power to the power supply. High voltages present under the power supply cover can be lethal.

Only one system fuse is located on the rear panel of the power supply (Figure 5). This is the power supply fuse.

The symbol illustrated below appears on the rear panel of the power supply. It indicates the location and specifications for system fuse replacement.



This 3 amp fuse also protects the filament transformer.

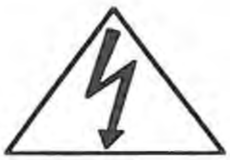
1 Switch off power at the main wall circuit breaker.

2 Remove the fuse by unscrewing the cap that seats the fuse into place.

3 Use an ohmmeter to measure the resistance of the fuse. The fuse should read approximately zero resistance.

4 If the fuse shows an open circuit condition, replace it.

Main Phase Fuse Replacement



Circuits in the power supply operate at high voltages. HIGH VOLTAGES CAN BE LETHAL. Use EXTREME CAUTION whenever operation without the power supply cover is required. Disconnect the main power before removing covers.

Inside the power supply there are three 70 A fuses for the three incoming power phases. These fuses are located just behind the cooling fan. To access or change these fuses, proceed as follows:

1 Switch off power at the main wall circuit breaker.

2 Unscrew the four knurled nuts which hold the fan in place at the rear of the power supply (Figure 5).

3 Slide out the fan assembly. The fuses are located immediately behind the fan.

4 Use an ohmmeter to measure the resistance of the fuses. Fuses should read approximately zero resistance.

5 Remove and replace fuses which show an open circuit condition.

6 Replace the fan assembly and tighten the knurled nuts finger-tight before reactivating the power source.

Failure Screening

The power supply front panel LED indicators (Figure 7) diagnose the status of the housekeeping power supply and the status of the main CPU. All LEDs should light when the system key is turned on. If any LEDs do not light, check the power supply system fuse (refer to Checking the System Fuse, above) and the main line fuses (refer to Main Phase Fuse Replacement, above). If all fuses are functional and one or more LED is still unlit, call the Coherent Technical Support Hotline.

Most system faults can be diagnosed through the remote control module providing the housekeeping power supply and the main CPU are functional. If a system problem occurs during operation which causes your laser to shut down, a fault message will be displayed on the LCD.

Study the chart which follows to determine which fault is causing the system failure. Where applicable, follow the directions to correct the fault.

If you are unable to correct the fault or your laser is still not performing to specifications, contact the Coherent Technical Support Hotline.

Please have the following information on hand when you telephone to discuss the problem with a Coherent Technical Support Engineer:

1. A detailed description of the failure event.
2. A list of which power supply status lights are out, if applicable.
3. The fault readout on the remote control module LCD.
4. The tube voltage at maximum tube current.
5. The cathode current at maximum tube current.
6. The serial number of the laser head.

Fault messages and their causes are listed in Table 13.

FAULT MESSAGE	PROBLEM	CHECKLIST[1]
Low Water Flow	Cooling water flow is below specification.	1 Is the water turned on? 2 Are there kinks or blockages in the water hoses? 3 Is a new water filter required? 4 Is the drain blocked? 5 Are the water hoses interchanged at the source/drain outlet end?
Low Fan Speed	Power supply fan is rotating too slowly.	1 Is the fan obstructed? 2 Are the electrical connections secure?
PS Interlock	Power supply interlock switch not closed.	1 Is the power supply cover installed?[2] 2 Are all cover screws installed?
Ext Interlock	External interlock connection not closed.	1 Is the external interlock connection closed? 2 Is the external interlock connected (Figure 4)?
Head Interlock	Head interlock switch(es) not closed.	1 Is the head cover installed?[2] 2 Are *all* cover screws installed? 3 Is the head/power supply connection secure?
Low I Shutdown	System has run for 100 hours at low current and requires autofill cycling.	1 Restart laser at 30 amps tube current. 2 Allow system to run at 30 amps until **Autofill Ok** message is displayed in Status Menu. 3 Resume normal operation
Over Temperature	Passbank temperature too high.	Does the inlet water temperature exceed specification?
Rem Communicat	Remote control module communication is unreliable.	1 Recycle the power supply system keyswitch. 2 Check connections.
Head Comm Error	Laser head communication has been lost.	1 Recycle the power supply system keyswitch. 2 Check connections.
Head/PS Mismatch	Improper match of head type vs. power supply type.	1 Recycle the power supply system keyswitch. 2 Head connector cable plugged into RS-232/422 connector?

[1] If, after verifying and/or correcting the checklist items, the system is still not operating, call Coherent Technical Support for assistance.

[2] If for maintenance purposes it is necessary to operate the laser with the covers off, then interlock defeats must be in place.

Table 13. System Fault Messages.

FAULT MESSAGE	PROBLEM	CHECKLIST[1]
Interlock Fault	Momentary failure of one of the interlock circuits.	Check all interlocks.
Remote Interlock	Remote control communication has been lost.	1 Recycle the power supply system keyswitch. 2 Check connections.
Low Pressure	Plasma tube under pressure.	1 Restart laser at 30 amps tube current. 2 Allow system to run at 30 amps until **Autofill Ok** message is displayed in Status Menu. 3 Resume normal operation
Low Cathode I	Cathode current too low.	Call Coherent Technical Support.
ReadyValve Fault	Autofill ready valve failure.	Call Coherent Technical Support.
Transistor Fault	Passbank transistors damaged.	Call Coherent Technical Support.
FillValve Fault	Autofill fill valve failure.	Call Coherent Technical Support.
High Passbank I	Passbank current too high.	Call Coherent Technical Support.
Low Starter Volt	Starter circuit voltage too low.	Call Coherent Technical Support.
PS EEPROM Error	Error detected in plasma tube calibration EEPROM.	Call Coherent Technical Support.
Over Voltage	Passbank voltage too high.	Call Coherent Technical Support.
High Cathode I	Cathode current too high.	Call Coherent Technical Support.
Low Magnet I	Magnet current too low.	Call Coherent Technical Support.
High Magnet I	Magnet current too high.	Call Coherent Technical Support.
TubeEEPROM Fault	Error detected in plasma tube calibration EEPROM.	Call Coherent Technical Support.
HeadEEPROM Fault	Error detected in plasma tube calibration EEPROM..	Call Coherent Technical Support.
Software Fault	Software execution error.	Call Coherent Technical Support.

[1] If, after verifying and/or correcting the checklist items, the system is still not operating, call Coherent Technical Support for assistance.

Table 13. System Fault Messages.

DIAGNOSTICS MENU

Items contained in the Diagnostics Menu provide expanded details about system operating parameters. These details can only be interpreted by Coherent Technical Support and Field Service Engineers. The information may be used by them to troubleshoot problems by telephone or on-site.

While on the telephone to Coherent Technical Support, your contact engineer may request data from the Diagnostics Menu. To enable you to supply this information, diagnostic menu items, along with a brief description of the information they contain, are listed below (Table 14).

MENU	SUB- MENU
DIGITAL	EEPROM_Status Read_Data Read_Address Vars/Const Remote_Status Init/Run/Stacks Head_Version Head_Messages Hd_Comm (Rtr._Err)
POWERTRACK	PT_DAC_A PT_Gain Low_High_MaxPwr Filter_Peak Find_Peak() Measure_PT_Gain PT_DAC_B
LIGHTREG	Lr_Lr_Mon_Flag Photocell_Gain Light_Reg_Errors Lr_Set_Point Lr_Lr_Mode Lr_Lightreg_Gain Lr_Vf_Vr Measur_Vfvr() Lr_Io_Cal Lr_Cal_Flag Cal_Light_Loop Lr_Pc_Mon_Flag
PHOTOCELL	Phc1_Phc2_Phc3
ANALOG	Autofill CathI_CathV_SP Fan_Speed

Table 14. Diagnostics Menu.

The Diagnostics Menu is available only through the Extended Menu which is normally inactive. The Extended Menu is activated by adjusting the dip switch panel labelled MY TALK ADDRESS on the rear of the power supply. Move dip switch number 8 to the up (on) position. Once the Extended Menu is activated, diagnostic menus and sub-menus can be accessed in the same way as other menus.

To enter diagnostics mode, press the MENU button and use the SCROLL buttons to scan through the menu until the display:

Diagnostics

appears in the LCD window.

Press the SELECT button and use the SCROLL buttons to scan the sub-menu of diagnostic modes until the desired item appears in the LCD window. Press SELECT to lock into the mode.

In the event of a system problem which you cannot resolve, the following short descriptions will assist you in troubleshooting your laser while on the telephone with Coherent Technical Support.

DIGITAL

The Digital Diagnostic Menu allows the operator to obtain information about the software currently on-line in the CPU.

To select a parameter, press the SELECT button and use the SCROLL buttons to scan the ancillary menu until the desired item appears in the LCD window. Press SELECT to lock into the mode.

EEPROM_Stat:

Shows status of EEPROM. 0=no fault. If a fault is present, additional information will be displayed on the second line.

Read_Data

Use in conjunction with **Read_Address**, below, to access values in RAM. The RAM and the data are displayed on the second line.

Read_Address

Use to select address number in RAM and then use **Read Data**, above to read the value at that address. The address is displayed on the second line.

Var/Const

Vars=1 and Const=1 indicates that all values read from the EEPROMs are verified.

Remote_Init_Reg._NN
Remote_Stat_Reg._NN

Indicates whether remote is working or not.

Init/Run/Stacks

This subroutine is used to test the software.

Head_Software

Shows version number of the software of the head CPU.

Head_Messages	Displays head messages. If an error exists, the last error message for the head communication link will be displayed on the second line.
Rtr:NN_ERR:NN R:NN_S:NN	Shows count of numbers of data sent to head (S), received from the head (R), number of retries (RTR) and the number of times that five consecutive errors have occurred (ERR).
POWERTRACK	The PowerTrack Diagnostic Menu allows the operator to ascertain the status of PowerTrack.
PT_DAC_A	Use SELECT to activate manual control for the PowerTrack solenoid A. Use the SCROLL and SET buttons to manually adjust the current through PowerTrack solenoid A (range 0-255).
Low_High_Maxpwr NN_NN_NN	Shows some significant light power readings during PowerTrack calibration.
Pt_Gain Max_Filter NN_NN_NN	Shows PowerTrack status values: 1=present gain, 2=maximum gain, 3=PowerTrack error signal.
Filter_Peak NN_NN	Shows two values for PowerTrack.
Find_Peak()	This subroutine individually peaks each PowerTrack solenoid. Press SET and it peaks one solenoid, press SET again and it will peak the other solenoid.
Measure_PT_gain NN_NN_NN	This subroutine is used to calibrate gain for PowerTrack. It shows three values: slope (Gain), height, and half-width at 50% power level.
PT_DAC_B	Use SELECT to activate manual control for the PowerTrack solenoid B. Use the SCROLL and SET buttons to manually adjust the current through PowerTrack solenoid B (range 0-255).
LIGHTREG	The LightReg Diagnostic Menu enables the operator to find out the status of light regulation.
Lr_LrMonFlag N	This flag is set by the light regulation software routine to enable/disable light regulation monitoring.

Photocell_Gain 0X_NN	This gain value (hex) displays the *actual* gain setting of the photocell amplifiers in the head.
Light_Reg_Errors NNNNNNNN	Checks for light regulation errors. A reading of all zeros means there are no faults.
Lr_SetPoint 0X_NNN	Displays the hex value of the light regulation DAC.
Lr_LrMode 0X_NN	Shows which of the three possible modes the system is presently running in: **0X17**=Current Regulation. **0X0F**=High gain Light Regulation. **0X07**=Low gain Light Regulation.
Lr_LightRegGain 0X_NN	Displays the hex values for Light Regulation gain.
Lr_Vf_Vr NN_NN	Shows two values of data used to calculate light regulation gain the last time it was measured.
Measur_VfVr() Press_Set	This subroutine measures the two values of data used to calculate Light Regulation gain by introducing a 2 KHz signal on the beam.
Lr_IOCal NN	Displays the current when the Light Regulation was last calibrated.
Lr_CalFlag	Shows the status of Light Regulation: **1**=Wide bandwidth **2**=Narrow bandwidth or current regulation.
CalLightLoop() Press_Set	Exercises a routine to redo calibration of high gain light regulation by introducing a 2 KHz signal on the beam.
Lr_PCMonFlag N	Enables/disables automatic gain setting of the photocell amplifier in the head, Use SELECT/SET to change the setting. **1**=Enable **0**=Disable

PHOTOCELL	The Photocell Diagnostic Menu allows the operator to obtain the status of the photocell.
PHC1_PHC2_PHC3 NN_NN_NN	Shows photocell values measured at three points between photocell and power supply.
ANALOG	The Analog Diagnostic Menu allows the operator to obtain information about miscellaneous items.
Autofill_NNNN E=N.NV_I=N.N A	Shows the Autofill timer, the error voltage and the present current. When the error voltage is negative, the timer is allowed to count down to zero and give the tube a fill. Time = 3000 counts equals 300 seconds
Cath.I_Cath.V_Sp NN_NN_NN	Displays the cathode current, voltage and set point. The values are direct ADC readouts without calibration.
Fan Speed NN	Shows the fan speed in relative units.

OPERATOR'S MANUAL

CHAPTER NINE
EXTERNAL COMPUTER CONTROL OF THE INNOVA 310/320 SERIES ION LASER

COHERENT

The autofill circuitry will only engage if the system is operating at the same current setting for five minutes. If your application requires frequent changes in current, run the system at full current for fifteen minutes at least once per day. This full current run will allow the autofill circuitry to bring the plasma tube to the correct pressure for tube operation.

Failure to maintain correct tube gas pressure will cause an under voltage fault which will shut down the system. In addition, running the plasma tube at lower-than-normal gas pressure for prolonged periods is harmful to the tube.

HOW TO INTERFACE THE INNOVA 310/320

This chapter provides details on how to interface an INNOVA 310/320 Series Ion Laser to a remote computer or to other analog/digital control electronics. Three different interface protocols are available through appropriate connectors on the rear of the power supply: RS-232/422, IEEE-488, and analog/digital control.

The RS-232/422 and IEEE-488 interfaces are based on a set of laser control instructions, consisting of commands that affect laser operation and queries that request the laser to return status information to the host. The instruction set is sufficient to support user-written programs that emulate the functions of the INNOVA 310/320 Remote Module.

The analog/digital interface is a set of TTL and analog lines that allow remote electronics to control the laser system. These electronics could consist either of a computer system equipped with analog/digital peripheral capability or of discrete, customized interface circuitry. This interface is described in a separate section at the end of this chapter.

RS-232/422 AND IEEE-488 COMMAND LANGUAGE

INSTRUCTION SYNTAX FOR RS-232/422 AND IEEE-488 COMMUNICATION

Communication with the INNOVA 310/320 is by two types of instructions: commands which set the values of laser operating parameters, and queries which request the laser to return the value of an operating parameter.

Any instruction to the laser consists of a command or query written as a string of ASCII characters and followed by a carriage return and linefeed (<CR><LF>).

For example:

PT=1<CR><LF> turns PowerTrack on.

PRINT LIGHT<CR><LF> requests the laser to return the laser output power.

The laser will always respond to an instruction by returning a message terminated by a carriage return and linefeed.

Table 15 lists the possible responses from the laser.

Do not send another instruction until a <CR><LF> has been received from the laser. Any characters transmitted to the laser during execution of a command may be ignored.

ECHO MODE

The INNOVA 310/320 provides an echo mode in which each character transmitted to the laser is echoed to the host. This feature can be turned on or off using the ECHO command (see below).

INSTRUCTION SENT TO LASER	RESPONSE FROM LASER ECHO OFF	RESPONSE FROM LASER ECHO ON
Command + <CR><LF>	<CR><LF>	Command + <CR><LF>
Query + <CR><LF>	Data [1] + <CR><LF>	Query + Data [1] + <CR><LF>
Command + <CR><LF> (illegal operand)	**Out of Range** + <CR><LF>	Command + **Out of Range** + <CR><LF>
Command or Query + <CR><LF> (illegal instruction)	**Syntax Error:** Command or Query + <CR><LF>	Command or Query + **Syntax Error:** Command or Query + <CR><LF>
Command + <CR><LF> (laser on, but command only allowed with contactor de-energized)	**Laser must be off** + <CR><LF>	Command + **Laser must be off** + <CR><LF>

[1] Multiple items will be separated by the **&** character. For example, a list of system faults will be returned as **Low Water Flow&PS Interlock&Head Interlock**.

Table 15. Response from Laser after Receiving Instruction

INSTRUCTION SET

The following list describes the instructions for use in RS-232/422 and IEEE-488 communication with the INNOVA 310/320.

COMMANDS	ACTION PERFORMED
LASER=N	If **N** is nonzero: energize the power supply main contactor and start the laser. If **N** is **0**: switch off the laser and de-energize the power supply main contactor.
CURRENT=NN.N	Set Current Regulation Mode at the specified current.
LIGHT=NN.NN	Set Light Regulation Mode at the specified output power.
WAVELENGTH=NNN	Set wavelength to a value from the following list. This command sets proper calibration of the laser internal power meter. For argon systems: **351, 364, 454, 457, 465, 472, 476, 488, 496, 501, 514, 528, 1090, MLVS, MLUV**.
FIELD=N	If **N** is nonzero: set the magnet to high field. If **N** is **0**: set the magnet to low field. This command will not execute once the system is in start delay or after the tube has ionized. It should be sent before the **LASER=1** instruction.
PT=N	If **N** is **0**: turn off PowerTrack. If **N** is **1**: turn on PowerTrack. If **N** is **2**: recalibrate PowerTrack. This command will execute only if PowerTrack is on and light regulation is off. If **N** is **3**: center PowerTrack and turn it off. This command is used to allow alignment of the high reflector mirror plate as in the Remote Module TUNE function.
ECHO=N	If **N** is **0**: Turn off echo. Characters transmitted to the laser will not be echoed to the host. If **N** is **1**: Turn on echo. Characters transmitted to the laser will be echoed to the host. A change in echo mode will take effect with the first command sent after the echo command.
BAUDRATE=NNN	Set the RS-232/422 baud rate to one of the following: **110, 300, 1200, 2400, 4800, 9600 or 19200.**
STATUS=N	Set pins 24 and 25 of the Analog Interface as detailed below: If **N** is **0**: Set pin 25 low, pin 24 low.

If **N** is **1**: Set pin 25 low, pin 24 high.
If **N** is **2**: Set pin 25 high, pin 24 low.
If **N** is **3**: Set pin 25 high, pin 24 high.

This command may be used to control an external device such as a shutter.

QUERIES	***RETURNED INFORMATION***
PRINT CURRENT	Return the calibrated tube current in amps to the nearest 0.1 amp. Format: NN.N
PRINT SET CURRENT	Return the current regulation set point in amps to the nearest 0.1 amp. Format: NN.N Note that data returned from this query is only meaningful if the laser system is operating in Current Regulation Mode (refer to **PRINT MODE**).
PRINT LASER	Return: **0** if the power supply main contactor is de-energized and the laser is off. **1** if the laser is in start delay (tube not ionized). **2** if the power supply main contactor is energized and the laser is on.
PRINT LIGHT	Return the calibrated light power output in watts to the nearest 0.01 W. Format: NN.NN
PRINT SET LIGHT	Return the light regulation set point in watts to the nearest 0.01 W. Format: NN.NN Note that data returned from this query is only meaningful if the laser system is operating in Light Regulation Mode (refer to **PRINT MODE**).
PRINT WAVELENGTH	Return the last wavelength setting as selected by any of the following: the remote control module, the RS-232/422 interface, the IEEE-488 interface, or the analog/digital interface.
PRINT FIELD	Return the measured magnet field: **1** = high field, **0** = low field. If the laser is off, this command will always return **0** (low field).

PRINT SET FIELD Return the selected magnet field setting: **1** = high field, **0** = low field.

PRINT PT Return the status of PowerTrack:

0 if PowerTrack is not installed.

-1 if PowerTrack is out of range.

1 if PowerTrack is off.

2 if PowerTrack is parked - PowerTrack is selected but the PowerTrack servo is inactive (this event occurs, for example, when PowerTrack is on and the operator closes the beamshutter).

3 if PowerTrack is on.

PRINT MODE Return:

0 if the laser is in current regulation.

1 if the laser is in reduced bandwidth light regulation.

2 if the laser is in standard light regulation..

PRINT FAULTS Return a list of all active faults separated by a **&** and terminated by a <CR><LF>.

PRINT HRSTILSHUTDOWN Return number of hours remaining before the laser system will be shut down automatically because it has run for 100 hours at low current. The system returns **100** to indicate an **Autofill Ok** condition. When the system undergoes Automatic Shutdown, it returns **0** in response to this query. (Refer to Chapter Five, Guide to Daily Operation.)

PRINT CONTROL Return the state of pin 10 of the Analog Interface:

0 if pin 10 is low.

1 if pin 10 is high.

This query may be used to determine the status of an external device such as a shutter.

PRINT STATUS Return the state of pins 24 and 25 of the Analog Interface:

0 Pin 25 is low, pin 24 is low.

1 Pin 25 is low, pin 24 is high.

2 Pin 25 is high, pin 24 is low.

3 Pin 25 is high, pin 24 is high.

? The single character **?** may be substituted for **PRINT** in all queries. For example:

? SET CURRENT

RS-232/422 Interface Connection

The INNOVA 310/320 Series Ion Laser RS-232/422 port configuration is described in Table 16, and typical cable requirements are diagrammed in Figure 34. The INNOVA 310/320 Series Ion Laser is a DCE device using only pins 2, 3 and 7. Handshake lines RTS, CTS, DTR and DSR (pins 4, 5, 20 and 6) are not used. RTS is connected to CTS and DTR is connected to DSR inside the INNOVA 310/320 power supply.

Port Configuration

Configuration	DCE, no handshaking
Data bits	8
Stop bits	1
Parity	none
Baud rate	User selectable: 110 300 1200 (factory setting) 4800 9600 19200
Signal connections inside power supply	RTS to CTS, DTR to DSR

Table 16. RS-232/422 Description.

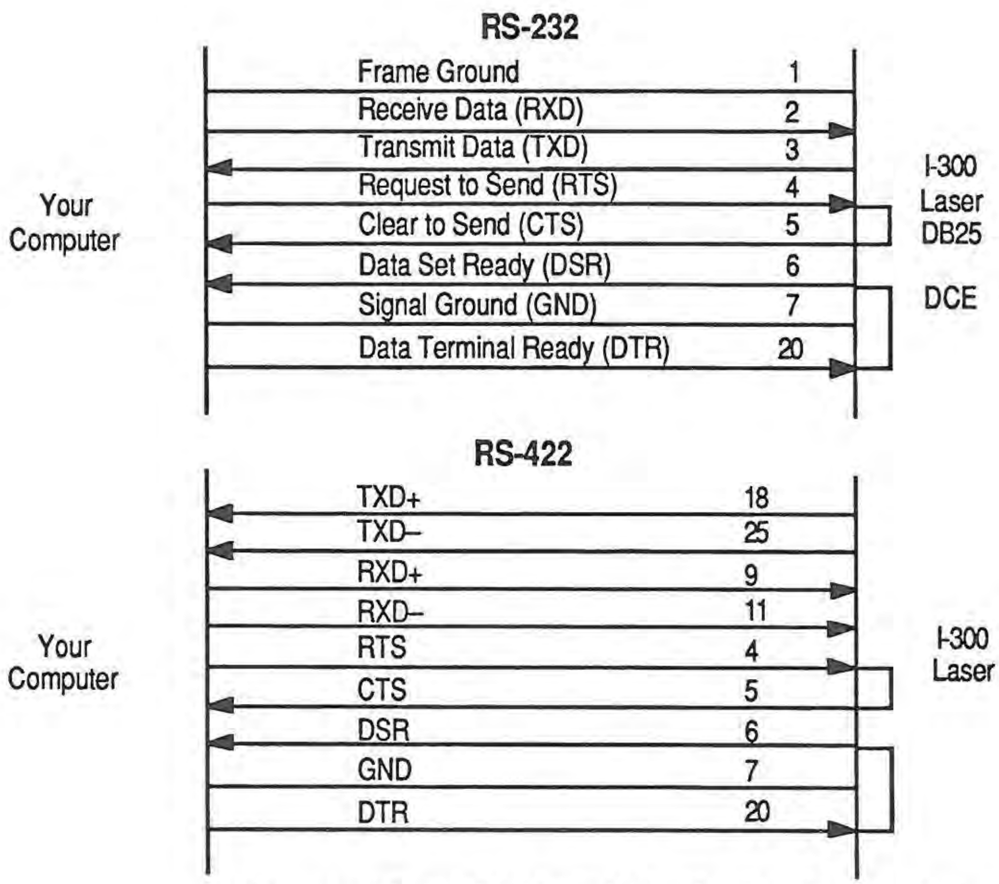


Figure 34. RS-232/RS-422 Pin Configurations.

SETTING THE BAUD RATE

The baud rate can be adjusted through the remote module or by means of the BAUDRATE=NNN command described above. After the baud rate is changed, the new setting will be used until it is changed (even if the system power is switched off).

To set the baud rate using the remote module:

1. Enable access to the Extended Menu by setting switch 8 on the MY TALK ADDRESS Dip Switch panel on the rear panel of the power supply to the up (on) position.
2. Use the remote control module to enter the Extended Menu as you would other menus. Scroll through the Extended Menu options and SELECT Baud Rate.
3. Scroll through the Baud Rate options displayed and SET the option you want.
4. Set switch 8 on the MY TALK ADDRESS Dip Switch panel to the down (off) position.

To set the baud rate by the remote computer, send the **BAUDRATE=NNN** command to the laser at the currently set baud rate. After sending this baudrate command, you must reinitialize the host computer communications port to the new baudrate.

The factory set baud rate is 1200.

RS-232 PROGRAMMING

A program can be written in interpreted BASIC to emulate the remote control module. Refer to the flowchart in Figure 35 for a simplified version of such a program.

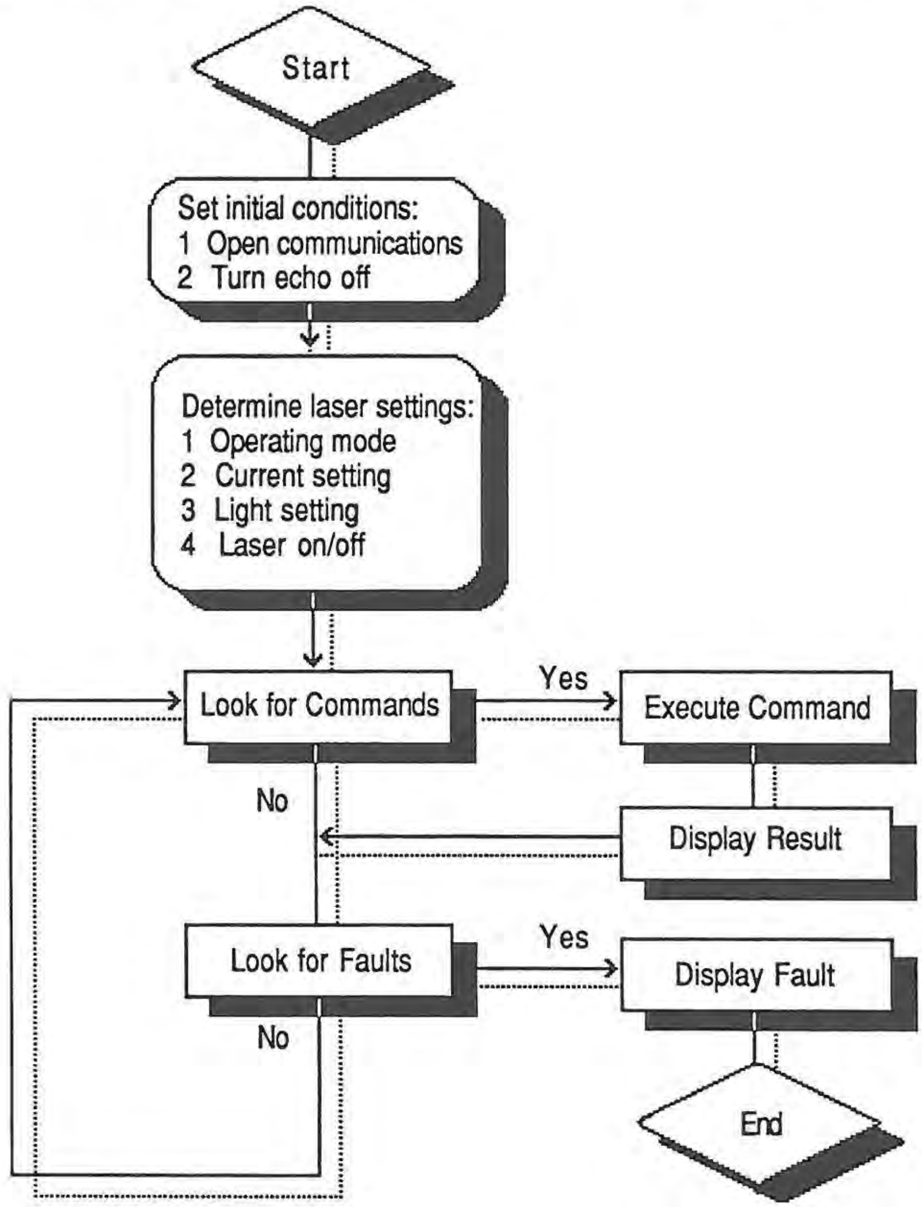


Figure 35. Flowchart of Simplified RS-232 Program.

Listing 1 is a program written in BASIC which allows you to interactively explore the possibilities of RS-232 control of the laser. Use the commands and queries as described above to operate the laser.

```
100 'I3DEMO.BAS
110 'RS-232 interface:    I300 demonstration program
120 'program assumes baud rate = 1200 baud
200 'initialize
210 KEY OFF:LOCATE 1,1,0:CLS
220 SECS=60*60*24 '                                      seconds in day
400 'open com1:, get laser status
410 OPEN "COM1:1200,N,8,1,CS,DS" AS #1 '                 open com 1
420 CMD$="ECHO=0":GOSUB 1000 '                           echo off
430 CMD$="?MODE": GOSUB 1000 '                           get mode
440 IF RESP$="0" THEN MODE$="Current"
450 IF RESP$="1" OR RESP$="2" THEN MODE$="Light"
460 CMD$="?SET CURRENT":GOSUB 1000 '                     get current setting
470 SETCURRENT$=RESP$ '
480 CMD$="?SET LIGHT":GOSUB 1000 '                       get light setting
490 SETLIGHT$=RESP$
500 CMD$="?LASER":GOSUB 1000 '                           get laser on/off
510 IF RESP$="0" THEN LASER$="Off"
520 IF RESP$="2" THEN LASER$="On"
530 IF RESP$="1" THEN LASER$="Start Delay"
600 'display initial status
610 LOCATE 1,22:PRINT "Innova 300 RS-232 Computer Control"
620 LOCATE 4,1:PRINT "Initial System Status:  Laser:         ";Laser$
630 LOCATE 5,25:PRINT "Operating Mode:   ";MODE$
640 LOCATE 6,25:IF MODE$="Current" THEN PRINT "Current Setting:   ";SETCURRENT$ ELSE
    PRINT "Light Setting:   ";SETLIGHT$
650 LOCATE 8,1:PRINT "Enter RS-232 commands as detailed in the Innova 300";
    "Operator's Manual":PRINT "to control the laser system. Press Q to end program."
700 'command loop
710 LOCATE 12,1:PRINT "Command:   ",:
720 INPUT "",CMD$ '                                      get command
730 IF CMD$="Q" OR CMD$="q" THEN 1200 '                  test for quit
740 LOCATE 14,12:PRINT SPACE$(40)
750 LOCATE 16,1:PRINT SPACE$(40)
760 LOCATE 17,1:PRINT SPACE$(40)
770 GOSUB 1000 '                                         send command
780 LOCATE 14,1:PRINT "Response:  ",RESP$ '              display response
790 LOCATE 16,1:PRINT  "Checking for faults. . ."
800 CMD$="?FAULTS":GOSUB 1000 '                          look for faults
810 LOCATE 17,1:PRINT RESP$
```

```
870  LOCATE 12,12:PRINT SPACE$(40)
890  GOTO 700
1000 'com routine
1005 PRINT #1,CMD$  '                                  send command
1010 C%=0
1015 WHILE EOF (1)  '                                  wait for response
1020 C%=C%+1:IF C%>2000 THEN COMERR%=1:GOTO1200  '     check for timeout
1025 WEND
1030 T=TIMER:IF SECS-T<.35 THEN 1035 ELSE 1045  '      midnight trap
1035 WHILE TIMER>0: WEND  '                            wait for midnight
1040 T=TIMER  '                                        get new time start
1045 WHILE TIMER<T+.3  '                               delay
1050 WEND
1055 A$=INPUT$(LOC(1),#1)  '                           get output
1060 T%=INSTR(A$,"System OK")
1065 IF T%>0 THEN RESP$="No active faults.":GOTO 1090
1070 LENA%=LEN(A$)  '                                  set a$ length
1075 GOSUB 1100  '                                     parse a$
1090 RETURN
1100 'parse routine: strip cr/lf
1110  RESP$=""
1120 FOR I%=1 TO LENA%
1130  TEST$=MID$(A$,I%,1)
1140  IF ASC(TEST$)>47 AND ASC(TEST$)<58 THEN RESP$=RESP$+TEST$:GOTO 1190
1150  IF TEST$="." THEN RESP$=RESP$+TEST$:GOTO 1190
1160  IF ASC(TEST$)>64 AND ASC(TEST$)<123 THEN RESP$=RESP$+TEST$:GOTO  1190
1170  IF TEST$="-" THEN RESP$=RESP$+TEST$:GOTO 1190
1180  IF TEST$=" " THEN RESP$=RESP$+TEST$:GOTO 1190
1190 NEXT
1195 RETURN
1200 'end
1210 LOCATE 20,1
1220 IF COMERR%=1 THEN PRINT "Communications error detected."
1230 PRINT "Program terminated.":PRINT
1240 CLOSE
1250 END
```

Listing 1. BASIC Program for RS-232 Control of Laser

IEEE 488 Operation

INNOVA 310/320 Series Ion Laser systems may be controlled by a remote computer which is connected to the IEEE 488 connector on the rear panel of the power supply. The laser system can be controlled by using the interface commands described in RS-232/422 and IEEE 488 Command Language above.

The IEEE 488 bus is a byte parallel interface bus (refer to: ANSI/IEEE Std. 488-1978, IEEE Standard Digital Interface for Programmable Instrumentation and IEEE Std. 728-1982, IEEE Recommended Practice for Code and Format Conventions).

Each device on the IEEE 488 bus has a unique talk/listen address. The INNOVA 310/320 Series Ion Laser address is determined by the first five switches of the MY TALK ADDRESS dip switch (0=off=closed, 1=on=open).

SW5	SW4	SW3	SW2	SW1	
0	0	0	0	0	MLA, MTA = 0
0	0	0	0	1	MLA, MTA = 1
0	0	0	1	0	MLA, MTA = 2
0	0	0	1	1	MLA, MTA = 3
0	0	1	0	0	MLA, MTA = 4
		•			
		•			
		•			
		•			
1	1	1	0	1	MLA, MTA = 29
1	1	1	1	0	MLA, MTA = 30

Table 17. My Talk Address Dip Switches.

Interface Protocol

Each command or query is ASCII text and must be followed by a carriage return and linefeed <CR><LF>.

The INNOVA 310/320 Series Ion Laser will answer each instruction with a message as described in Table 15. The message will be terminated by a carriage return and linefeed (<CR><LF>). In order to keep communication between computer and laser synchronized, it is essential to read the message returned by the laser. If the message is not retrieved, it will stay in the output buffer of the laser system until the next time the laser is addressed as talker.

ECHO MODE

Though echo on mode may be used in IEEE 488 communications, it is not recommended. As the IEEE 488 interface operates in a handshake mode, turning echo on will complicate data reception without adding value. Communications problems can be detected easily by monitoring bus status variables. The sub-programs and macros necessary for read/write operations, monitoring bus status variables, etc., are usually supplied by the manufacturer of the IEEE 488 computer interface board.

IEEE 488 PROGRAMMING

Listing 2, written in QuickBASIC, shows how to change laser tube current from the computer keyboard and how to read the measured tube current from the laser system.

```
' This demo program changes the laser current to a value entered from
' the keyboard and reads the measured current back from the laser.
' MicroSoft QuickBASIC; Macintosh SE; National Instruments GPIB-SEP board.

' open the library (Supplied by National Instruments)
LIBRARY "QuickBASIC488.lib"
'           initialize the GPIB bus status variables so the library can write to them.
ibsta%=0 : iberr%=0 : ibcnt&=0
' tell the library what status variable to write to.
CALL ibinit(ibsta%, iberr%,ibcnt&)
' initialize device identifier
i300%=0
' device name as established with the configuration program "ibconf"
devnme$="i300"
' opens device with name devnme$ and assigns value to identifier i300%;
' i300% used with routines ibwrt and ibrd
' on GPIB bus error subprogram fail will print an error message and stop program
CALL ibfind(devnme$,i300%) : IF ibsta%<0 THEN CALL fail("opening device")

' Change laser current to a value entered from the keyboard
   ' initialize read variables; allow enough spaces for the message from the laser
  response$=SPACE$(30)
  INPUT "laser current";current!
   ' all instructions to the laser have to be terminated by
  ' <CR><LF>:CHR$(13)+CHR$(10)
   current$="current="+STR$(current!)+CHR$(13)+CHR$(10)
```

```
    ' ibwrt: addresses board as talker and device i300% as listener;
    ' sends message current$ to device i300% and updates bus status variables
    CALL ibwrt (i300%, current$): IF ibsta%<0 THEN CALL fail("setting current")
    ' The laser responds to every command sent with at least a <CR><LF>.
    ' This response must be read from the laser to clear the message buffer
    ' ibrd: sets board as listener and device i300% as talker;
    ' receives message response$ from i300% and updates bus status variables
    CALL ibrd(i300%, response$): IF ibsta%<0 THEN CALL fail("reading response")
    PRINT "Laser response: ";response$
    ' waiting for current to settle to new value
    FOR j=1 TO 200: NEXT j

'   reading current from laser
    prompt$="PRINT CURRENT"+ CHR$(13) + CHR$(10)
    readcurrent$=SPACE$(30)
    CALL ibwrt (i300%, prompt$): IF ibsta%<0 THEN CALL fail("prompting current")
    CALL ibrd (i300%, readcurrent$): IF ibsta%<0 THEN CALL fail("reading current")
    PRINT "Measured current: ";readcurrent$
END

SUB fail(failure$) STATIC: PRINT "GPIB bus failure while ";failure$: STOP: END SUB
```

Listing 2. QuickBASIC Program for IEEE 488 Operation.

HEX	OCT	DEC	ASCII	IEEE MSG	HEX	OCT	DEC	ASCII	MSG
00	000	0	NUL		20	040	32	SP	MLA0
01	001	1	SOH	GTL	21	041	33	!	MLA1
02	002	2	STX		22	042	34	"	MLA2
03	003	3	ETX		23	043	35	#	MLA3
04	004	4	EOT	SDC	24	044	36	$	MLA4
05	005	5	ENQ	PPC	25	045	37	%	MLA5
06	006	6	ACK		26	046	38	&	MLA6
07	007	7	BEL		27	047	39	'	MLA7
08	010	8	BS	GET	28	050	40	(	MLA8
09	011	9	HT	TCT	29	051	41	)	MLA9
0A	012	10	LF		2A	052	42	*	MLA10
0B	013	11	VT		2B	053	43	+	MLA11
0C	014	12	FF		2C	054	44	,	MLA12
0D	015	13	CR		2D	055	45	-	MLA13
0E	016	14	SO		2E	056	46	.	MLA14
0F	017	15	SI		2F	057	47	/	MLA15
10	020	16	DLE		30	060	48	0	MLA16
11	021	17	DC1	LLO	31	061	49	1	MLA17
12	022	18	DC2		32	062	50	2	MLA18
13	023	19	DC3		33	063	51	3	MLA19
14	024	20	DC4	DCL	34	064	52	4	MLA20
15	025	21	NAK	PPU	35	065	53	5	MLA21
16	026	22	SYN		36	066	54	6	MLA22
17	027	23	ETB		37	067	55	7	MLA23
18	030	24	CAN	SPE	38	070	56	8	MLA24
19	031	25	EM	SPD	39	071	57	9	MLA25
1A	032	26	SUB		3A	072	58	:	MLA26
1B	033	27	ESC		3B	073	59	;	MLA27
1C	034	28	FS		3C	074	60	<	MLA28
1D	035	29	GS		3D	075	61	=	MLA29
1E	036	30	RS		3E	076	62	>	MLA30
1F	037	31	US		3F	077	63	?	UNL

Table 18. ASCII Table for RS-232 and IEEE 488 (IBM PC).

HEX	OCT	DEC	ASCII	IEEE MSG	HEX	OCT	DEC	ASCII	MSG
40	100	64	@	MTA0	60	140	96	`	MSA0,PPE
41	101	65	A	MTA1	61	141	97	a	MSA1,PPE
42	102	66	B	MTA2	62	142	98	b	MSA2,PPE
43	103	67	C	MTA3	63	143	99	c	MSA3,PPE
44	104	68	D	MTA4	64	144	100	d	MSA4,PPE
45	105	69	E	MTA5	65	145	101	e	MSA5,PPE
46	106	70	F	MTA6	66	146	102	f	MSA6,PPE
47	107	71	G	MTA7	67	147	103	g	MSA7,PPE
48	110	72	H	MTA8	68	150	104	h	MSA8,PPE
49	111	73	I	MTA9	69	151	105	i	MSA9,PPE
4A	112	74	J	MTA10	6A	152	106	j	MSA10,PPE
4B	113	75	K	MTA11	6B	153	107	k	MSA11,PPE
4C	114	76	L	MTA12	6C	154	108	l	MSA12,PPE
4D	115	77	M	MTA13	6D	155	109	m	MSA13,PPE
4E	116	78	N	MTA14	6E	156	110	n	MSA14,PPE
4F	117	79	O	MTA15	6F	157	111	o	MSA15,PPE
50	120	80	P	MTA16	70	160	112	p	MSA16,PPE
51	121	81	Q	MTA17	71	161	113	q	MSA17,PPE
52	122	82	R	MTA18	72	162	114	r	MSA18,PPE
53	123	83	S	MTA19	73	163	115	s	MSA19,PPE
54	124	84	T	MTA20	74	164	116	t	MSA20,PPE
55	125	85	U	MTA21	75	165	117	u	MSA21,PPE
56	126	86	V	MTA22	76	166	118	v	MSA22,PPE
57	127	87	W	MTA23	77	167	119	w	MSA23,PPE
58	130	88	X	MTA24	78	170	120	x	MSA24,PPE
59	131	89	Y	MTA25	79	171	121	y	MSA25,PPE
5A	132	90	Z	MTA26	80	172	122	z	MSA26,PPE
5B	133	91	[	MTA27	81	173	123	{	MSA27,PPE
5C	134	92	\	MTA28	82	174	124	|	MSA28,PPE
5D	135	93	]	MTA29	83	175	125	}	MSA29,PPE
5E	136	94	^	MTA30	84	176	126	~	MSA30,PPE
5F	137	95	_	MTA31	85	177	127	DEL	

Table 18. ASCII Table for RS-232 and IEEE 488 (IBM PC).

ANALOG INTERFACE

The INNOVA 310/320 Series Ion Laser can be controlled by means of a set of control lines accessed through the Analog Interface connector on the rear of the power supply (Figure 5). The function of each pin is described in Tables 19 and 20.

INPUT LINES

PIN NUMBER	FUNCTION
Digital (TTL levels)	
9, 8, 7	Select the range of the internal power monitor 000 = 0.2 W 011 = 2.0 W 110 = 20.0 W 001 = 0.5 W 100 = 5.0 W 111 = Interface disabled 010 = 1.0 W 101 = 10.0 W
13, 12	Select the wavelength for calibration of the internal power monitor Argon: 00 = 514 nm, 01 = 488 nm, 10 = 457 nm, 11 = MLUV Krypton: 00 = MLRD, 01 = 568 nm, 10 = MLVI, 11 = MLUV
10	Read by RS-232 query **PRINT CONTROL.**
11	System ON/OFF. TTL high turns the system on. The system will remain on as long as the line remains high.
Analog (0-5 VDC with 8 bit resolution)	
4	Laser power input. 5 V (resolution = range/255) represents full power on the range selected by pins 7-9.
5	Laser current input. 5 V = 100 A and 1 V = 20 A (resolution = 0.392 A).

Table 19. Analog Interface Input Lines.

OUTPUT LINES

PIN NUMBER	FUNCTION
Digital (TTL levels)	
23, 22, 21	000 No faults 001 Cathode fault 010 Water Flow fault 011 No magnetic field 100 Interlock fault 101 Autofill fault 110 Three transistor failure 111 Other fault
25,24	Set by RS-232 command **STATUS=N**: 00 **STATUS=0** 01 **STATUS=1** 10 **STATUS=2** 11 **STATUS=3**
Analog (0-5 VDC @ 8 bit resolution)	
2	Laser output power as measured by the internal power monitor. 5 V represents full scale on the range selected by bits 7-9.
3	Laser tube current. 5 V = 100 A and 1 V = 20 A (resolution = 0.392 A).

Table 20. Analog Interface Output Lines.

PIN NUMBER	FUNCTION		
Interlock Lines			
20	+24 V		
19	External interlock. To complete the interlock loop, connect pin 19 to pin 20.		
Other Lines			
15	Gnd		
16	Gnd		
17	Gnd		
18	Gnd		
1	+5 V		
14	+5 V		
6	Unused		
Note: TTL Levels			
TTL Inputs	Vih	2.0 V	Voltage input high
	Vil	0.8 V	Voltage input low
	Iih	0.02 mA	Current input high (sink)
	Iil	-0.2 mA	Current input low (source)
TTL Outputs	Voh	2.4 V	Voltage output high
	Vol	0.5 V	Voltage output low
	Ioh	-0.4 mA	Current output high (source)
	Iol	8 mA	Current output low (sink)

Table 20. Analog Interface Output Lines.

Interface Response Time

The following is a summary of typical and maximum response times for input and output signals of the Analog Interface:

INPUT:

Current Regulation	100 msec	200 msec	Analog input current change to change in laser current.
Light Regulation	3 sec	10 sec	Analog input power change to stable laser power with Power Track enabled. Response time includes time needed by laser system to achieve stable operation at new setting.

OUTPUT:

Current or Light Regulation	200 msec	500 msec	Change in laser current or power to change in output voltage on interface.

INNOVA® 310/320 Series Ion Laser

Operator's Manual

Appendix A
Spare Parts and Accessories

COHERENT®

SPARE PARTS

Listed below are user-installable spare parts for the INNOVA 310/320 Series Ion Laser. It is recommended that you keep sufficient spares on hand so that routine maintenance procedures can be carried out without interrupting your laser operation.

Tables 22 lists the output mirrors available for the INNOVA 310/320 Series Ion Laser.

Spare parts and optics are available by contacting Coherent Customer Service.

ITEM DESCRIPTION	QUANTITY SUPPLIED	COHERENT PART NO.
Fuse, 70 A	3	5110-0233
Fuse 3 A 250 V, slow blow	1	5110-0086
Replacement Water Filter Cartridge*	—	2603-0016
Spare Key	1	N/A
O-ring (water fittings)	10	2501-0055
Duplicates of optics ordered with the unit*	—	Table 22

*Spares not included with system.

Table 21. Recommended Spare Parts.

MODEL	WAVELENGTH	PART NO.	RADIUS (M)	TRANS (%)	COMMENTS
325/326	333.6-363.8	0161-802-00	8	1.5	UV full bandwidth
325/326	351.1-363.8	0161-801-00	8	1.5	UV limited bandwidth
318	457.9-514.5	0161-443-00	10	5	Multiline visible

Table 22. Output Mirrors.

REPLACEMENT PARTS

Additional replacement parts and their part numbers are listed in Table 23.

COHERENT PART NO.	ITEM DESCRIPTION
0160-089-00	Assembly, Electro-Magnet (PowerTrack)
0160-260-00	Assembly, Emission Light
0160-322-00	PCB Assembly, Control
0160-448-00	PCB Assembly, Head Driver
0160-451-00	PCB Assembly, Housekeeper
0160-507-00	Remote Module, I300
0160-612-00	Assembly, Shutter/Aperture
0160-613-00	Assembly, Front Mirror Mount (w/ PowerTrack)
0160-734-00	Assembly, Cooling Fan
0160-735-00	Assembly, Flow Transducer
0160-736-00	P/S Assembly, I300 (FRU)
0160-852-00	Filter Choke, 0.5 mH, 80 A
0160-853-00	Transformer, Filament (325/326)
0160-854-00	Assembly, Softstart Relay
0160-881-00	Magnet Assembly, I300 Argon
0160-881-02	Magnet Assembly (318)
0160-885-00	Passbank Assembly, I300
0160-925-00	PCB Assembly, Motherboard
0161-083-00	Assembly, Aperture Extension (w/catl. screen)
0161-270-00	Assembly, Optic Holder (output)
0161-271-00	Assembly, Bellows
0161-804-00	Filament Transformer (318)
0409-070-05	Thermostat, Type 5003, 160
1501-1045	Cap, 1400MFD, 350 V
2200-0001	Transformer, LEM-100
2700-0001	Filter Elect, Powerline RF
2802-0118	2 Speed Screw
4501-0301	Relay, 30 A PB PRD3DY0 110VD (Softstart)
4501-0419	Relay (Magnet)
4501-0422	Contactor, 3P NO 50 A 200 V/240 V (325/326)

Table 23. INNOVA 310/320 Replacement Parts.

COHERENT PART NO.	ITEM DESCRIPTION
4501-0433	Contactor, 3P 600 VAC, 55 A (318)
4712-2518	Res, 10 OHM, 50 W, 1% (Softstart)
4802-0435	Starter Diode
4802-0507	Rectifier, 3 Phase
5105-0077	Switch, PS Interlock
5105-0082	Switch, Roll Leaf, 15 A, 12 (Magnet ground)
5106-0049	Switch, Waterflow, Brass
5302-0054	Thermostat, 125 V, 10 A
5110-0086	Fuse, 3A, 250V slow blow
5110-0233	Fuse
0160-614-02	Light Pick-off Assembly, I318
0160-614-01	Light Pick-off Assembly, I326/325
0160-944-00	Cathode Current Sense
0161-071-00	Starter Cable Assembly
0161-767-18	Replacement Tube I318
0161-805-25	Replacement Tube I325
0616-805-26	Replacement Tube I326

Table 23. INNOVA 310/320 Replacement Parts.

OPERATOR'S MANUAL

APPENDIX B
SUPPLEMENTARY PROCEDURES

COHERENT

CHANGING THE EPROM

From time to time, the software on the EPROM chip may be revised, or you may wish to change software to implement a new application. At this time, the EPROM chip on the controller board will be replaced. You can make this change as follows:

Use the IC extraction tool and the wrist-strap for ESD (Electrostatic Discharge) protection supplied by Coherent in the upgrade kit.

Circuits in the power supply operate at high voltages. HIGH VOLTAGES CAN BE LETHAL. Use EXTREME CAUTION whenever operation without the head cover or the power supply cover is required. If operation of the laser is not required for maintenance procedures, disconnect the main power before removing covers.

1. Shut down the laser and disconnect power.
2. Remove the screws which retain the power supply cover and remove the cover. The controller board is located immediately beneath the cover.

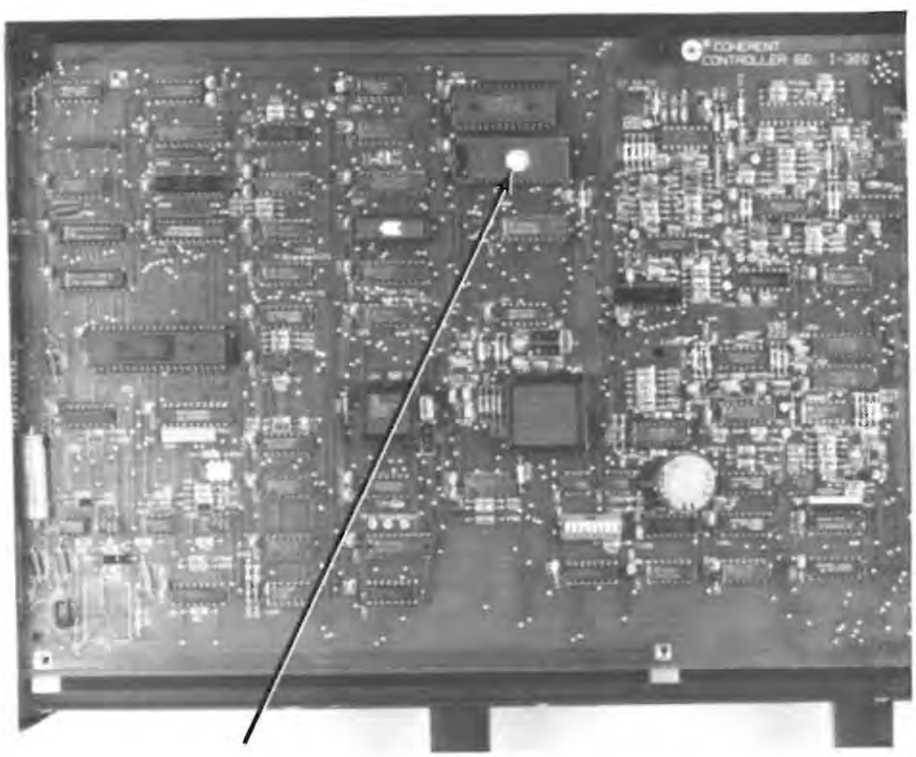


Figure 36. Controller Board Showing the Location of the EPROM IC.

3 Use the IC extraction tool and the wrist-strap for ESD (Electrostatic Discharge) protection supplied by Coherent in the upgrade kit.

4 Locate the EPROM IC (U40) and carefully remove the chip by gripping it with the IC tool and pulling firmly upwards. Refer to Figure 36.

5 Unpack the new EPROM IC. Save the antistatic bag and foam packaging for later use. Carefully insert the new chip as follows:

   a Make sure that no pins on the new EPROM IC are bent.

   b Carefully grip the chip with the IC tool. Ensure all the pins are in the correct position on the connector before pushing firmly downward.

   c Leave two pin positions per row empty in front of chip as shown in Figure 36.

6 Replace the power supply cover.

7 Restart the system.

8 Return the old EPROM to Coherent using the protective foam packaging, antistatic bag and shipping box supplied with the new EPROM.

Rotating the Umbilical on the Laser Head

To allow versatility in the location of the laser head, the umbilical assembly can be rotated from its normal position so that it hangs straight down from the end of the laser head. To make this change proceed as follows:

1 Shut down the laser and disconnect power.

2 Position the rear of the laser head so that at least six inches protrudes over the edge of the table.

3 Loosen the four screws which retain the umbilical mount to the rear bezel of the laser head.

4 Pull out slightly on the umbilical assembly to release it from its mount, and then push the umbilical downwards.

5 Rotate the bracket to align the four clearance holes on the bottom of the head.

6 Push the assembly firmly upwards until it seats in the new location (Figure 37) and tighten the four retaining screws.

7 Restart the system.

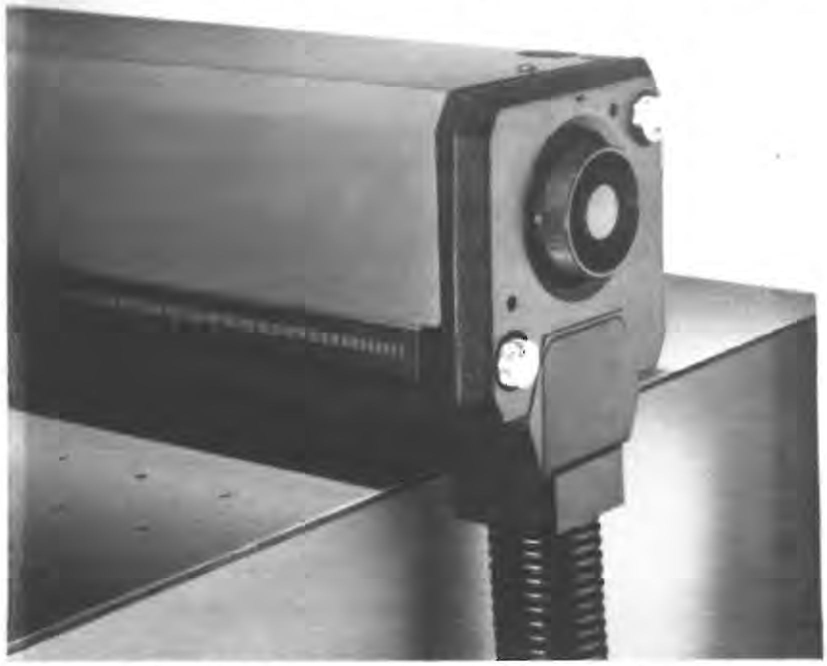


Figure 37. The Laser Head with the Umbilical Rotated to the Vertical Position.

Rotating the Umbilical on the Power Supply

Refer to Chapter Three, Utility Requirements and System Installation, for information on adjusting the angle at which the umbilical exits the power supply.

Rack Mount Slide Brackets

The INNOVA 310/320 Series Ion Laser power supply can be mounted into a standard 48.26 cm (19.00 in.) equipment rack.

Rack mount slide brackets for cabinet depths of approximately 76.20 cm (30.00 in.) are available for the power supply. If you order this option, the brackets and associated hardware will be packed in the box that contains the power supply.

Rack Mount Installation

Before commencing this procedure, switch off the laser system and disconnect power at the source. Detach the umbilical connections at the rear of the power supply.

1 Remove the handles on the sides of the power supply by removing the four socket head cap screws (two per handle accessed from outside the power supply) with a 3/16 in. Allen screwdriver.

2 Each Rack Mount slide bracket assembly is made up of three components: the chassis bracket (smallest),

the sliding bracket (the one in the middle), and the rack bracket (the largest). Disassemble the sliding bracket and rack bracket as a unit from the chassis bracket by depressing the lever exposed as the chassis bracket is pulled out from the other two brackets. The chassis bracket, has five mounting holes that match five holes with threaded inserts on each side of the power supply chassis.

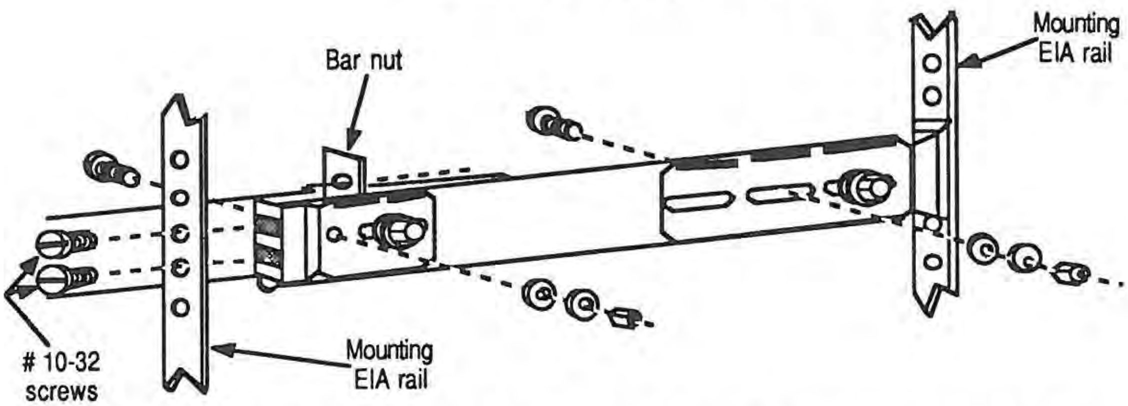


Figure 38. How to Mount Rack Brackets to an Equipment Rack.

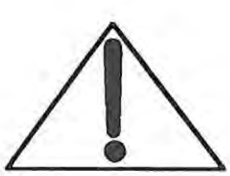
3 Using the hardware already installed on the power supply, mount one chassis bracket on each side of the power supply chassis. Mount them so the sliding brackets can be slid onto them and the spring lever is towards the rear of the chassis. Slide the sliding brackets onto the chassis brackets until they lock in place, extended from the rear of the power supply.

4 Mount the rack brackets (Coherent Part Number: 1403-0337) with the extensions (Coherent Part Number: 1403-0338) if needed, onto the equipment rack using the mounting hardware kit (Coherent Part Number: 1403-0340) as shown in Figure 38.

5 Align the power supply and sliding brackets to the rack brackets and slide the unit in as far as it will go. Push in on the spring lever locking mechanisms on the sliding brackets so the unit can be slid all the way in place.

6 Mount the handles to the angles using the #8-32 x 5/8 in. flat head screws.

7 Mount the angles to both front sides of the power supply using the top cover side screws so that the handles face forward.



The handles provided for the rack mount option are not intended to be used to carry the power supply if the unit is removed from the rack.

OUTPUT MIRROR WEDGE ANGLE PROCEDURE

Some INNOVA 310/320 Series Ion Lasers may not be equipped with output mirrors which are keyed to their mirror holders. To preserve the output mirror wedge angle position (Figure 39), follow the procedure below whenever removal or replacement of output mirrors is required.

Failure to follow this procedure will result in a change in beam direction which may necessitate a realignment of any optics in the beam path.

1 Rotate the aperture wheel to the open aperture (O) position for maximum power. Press TUNE and adjust for maximum power using the high reflector mirror tuning knobs.

2 The wedge gives rise to a secondary output beam (Figure 39 [1]). Lower the tube current so the output power is less than 1 W and affix a card in the beam about 30 cm (1 ft.) in front of the laser. Mark the position of the secondary beam relative to the main beam.

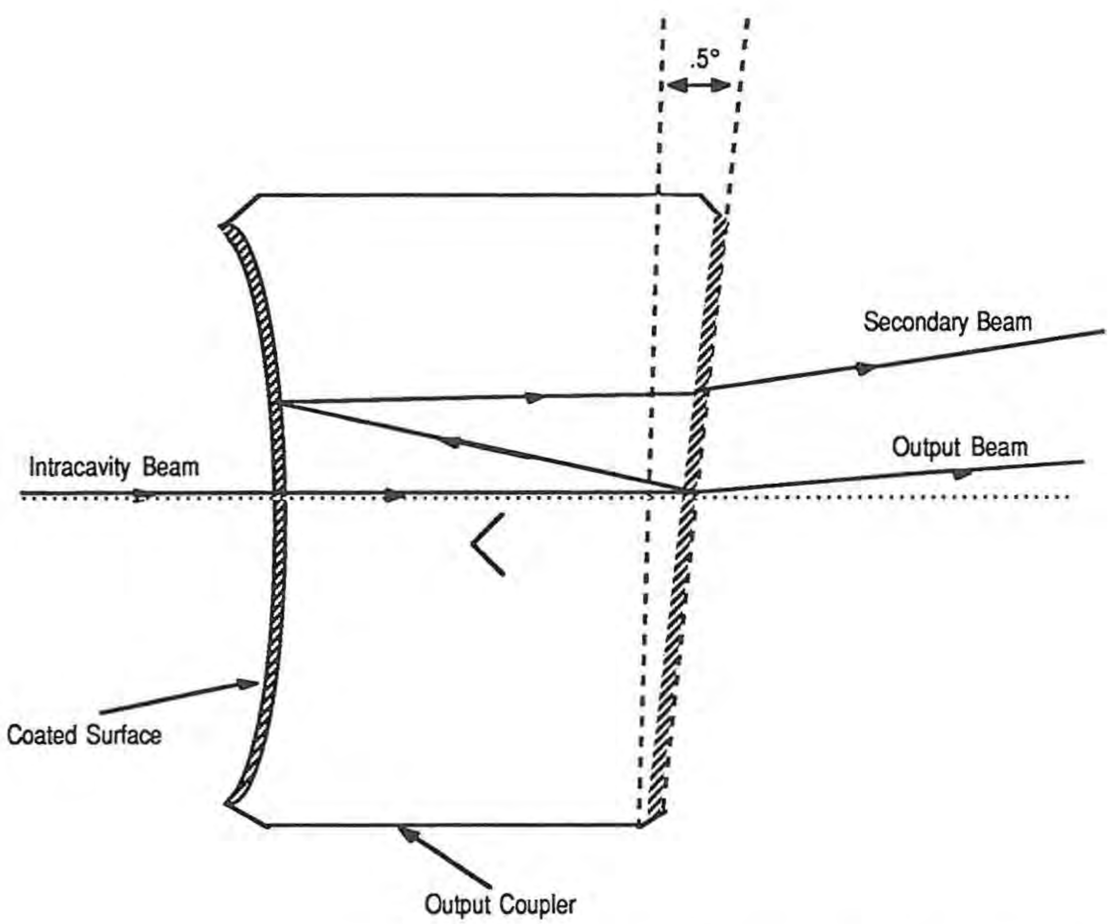


Figure 39. Output Mirror Showing Wedge Angle.

[1] The wedge angle has been exaggerated for clarity.

3 Close the beam shutter. Unscrew the knurled cap from the output mirror holder and remove the output mirror holder. The beam pick-off assembly is located inside the mirror holder and is cleaned separately.

Note the position of the arrow on the side of the output mirror in relation to the output mirror holder so the optic can be replaced exactly. Follow this step to avoid a shift in position of the output beam arising from the wedge in the optic.

4 Reverse the output mirror in its holder and clean the outer surface first.

5 Return the output mirror to its original orientation with the arrow pointing away from the holder. Rotate the mirror so the arrow is in the same position as before. Clean the exposed inner surface of the mirror.

6 Replace the output mirror holder and beam pick-off assembly and replace the knurled cap.

7 Open the shutter. In tune mode, adjust for maximum power using the high reflector mirror tuning knobs. Check the relative position of the secondary beam on the card. If the position has changed, close the shutter, remove and rotate the mirror and recheck.

8 Rotate the aperture wheel to the desired setting.

9 Press TUNE to return to the default display.

INNOVA® 310/320 SERIES ION LASER

OPERATOR'S MANUAL

APPENDIX C
WARRANTY

COHERENT®

Ion Laser Warranty

Coherent, Inc. warrants to the original purchaser (the Buyer) only, that the INNOVA laser, that is the subject of this sale, (a) conforms to Coherent's published specifications and (b) is free from defects in materials and workmanship.

The standard warranty terms and conditions for INNOVA lasers are listed below. If desired, the standard warranty can be modified to more exactly meet the needs of an individual Buyer. Contact your local Coherent Service Representative for information on warranty modifications.

INNOVA Series Ion Laser systems are warranted for parts and labor for a period of eighteen (18) months or 2000 hours of operation, whichever occurs first. Travel expenses are also included for the first ninety (90) days. For systems that do not include installation in the purchase price, warranty begins from the date of shipment. For systems that include installation, warranty begins at the date of installation or thirty (30) days from the date of shipment, whichever occurs first.

IonPure Plasma Tubes

IonPure replacement plasma tubes are warranted for parts and labor for a period of twelve (12) months or 2000 hours of operation, whichever occurs first. Travel expenses are also included for the first ninety (90) days. Tube warranty begins from the date of installation, or thirty (30) days from the date of shipment, whichever occurs first.

Extended Warranty

Warranty extensions are available for INNOVA Series Ion Laser systems at the time of original purchase. The warranty may be extended without limit. Contact your local Coherent Service Representative for information on warranty modifications.

Service Agreements

Service agreements are available for all Coherent INNOVA Series Ion Laser systems and may be purchased at any time, whether or not the system is currently under warranty. If a system is out of warranty, a service visit may be required to ensure the system is up-to-date and meets all specifications. The customer will be charged for all parts and labor necessary to bring the system up-to-date and within specifications prior to the start of any service agreement. Contact your local Coherent Service Representative for information on service agreements.

Conditions of Warranty

On-site warranty services are provided only at the installation point. If products eligible for on-site warranty and installation services are moved from the original installation point, the warranty will remain in effect only if the Buyer

purchases additional inspection or installation services at the new site.

For warranty service requiring the return of any product to Coherent, the product must be returned to a service facility designated by Coherent. The Buyer is responsible for all shipping charges, taxes and duties covered under warranty service.

Parts replaced under warranty shall become the property of Coherent and must be returned to Coherent, Inc., Palo Alto, or to a facility designated by Coherent. All laser plasma tubes must be carefully packed in the shipping containers provided by Coherent. Coherent does not assume responsibility for tubes broken in shipment due to improper packaging or handling. The Buyer will be obligated to issue a purchase order for the value of the replaced parts and Coherent will issue credit when the parts are received.

Other Products

Other products not specifically listed above are warranted to: (a) conform to Coherent's published specifications and (b) be free from defects in materials and workmanship. This warranty covers parts and labor and is for a period of twelve (12) months from the date of shipment.

Responsibilities of the Buyer

The Buyer must provide the appropriate utilities and operating environment outlined in the Preinstallation Manual. Damage to the INNOVA Series Ion Laser system caused by failure of Buyer's utilities or the Buyer's failure to maintain an appropriate operating environment, is solely the responsibility of the Buyer and is specifically excluded from any warranty, warranty extension, or service agreement.

The Buyer is responsible for prompt notification to Coherent of any claims made under warranty. In no event will Coherent be responsible for warranty claims later than seven (7) days after the expiration of the warranty.

Limitations of Warranty

The foregoing warranty shall not apply to defects resulting from:

1 Components or accessories with separate warranties manufactured by companies other than Coherent.

2 Improper or inadequate maintenance by Buyer.

3 Buyer-supplied interfacing.

4 Operation outside the environmental specifications of the product.

5 Improper site preparation and maintenance.

6 Unauthorized modification or misuse.

Coherent assumes no responsibility for customer-supplied material.

The obligations of Coherent are limited to repairing or replacing, without charge, equipment which proves to be defective during the warranty period. Replacement tubes may contain reconditioned parts. Repaired or replaced parts are warranted for the duration of the original warranty period only. This warranty does not cover damage due to misuse, negligence or accidents, or damage due to installations, repairs or adjustments not specifically authorized by Coherent.

This warranty applies only to the original Buyer at the initial installation point in the country of purchase, unless otherwise specified in the sales contract. Warranty is transferable to another location or to another Buyer only by special agreement which will include additional inspection or installation at the new site.

THE WARRANTY SET FORTH ABOVE IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTY, WHETHER WRITTEN, ORAL OR IMPLIED and DOES NOT COVER INCIDENTAL OR CONSEQUENTIAL LOSS. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

COMMONLY USED ABBREVIATIONS

°C--------------degrees centigrade or Celsius

°F--------------degrees Fahrenheit

A --------------amperes

AC -------------alternating current

BTU ------------British thermal unit

CDRH ---------Center for Devices and Radiological Health (U.S. Government)

cm -------------centimeters

DC -------------direct current

Hz--------------Hertz or cycles per second (frequency)

kg --------------kilograms

kPa-------------kilopascals (pressure)

kW--------------kilowatts = 10^3 watts

l-----------------liters (volume)

lbs -------------pounds

mA -------------Milliamps

MHz -----------megahertz = 10^6 Hz

mg -------------milligrams

mm -----------millimeters

mrad ----------milliradians (angle)

nm--------------nanometers = 10^{-9} m (wavelength)

OEM-----------Original Equipment Manufacturer

psi -------------pounds per square inch

RMS------------root mean square

TEM -----------transverse electromagnetic (cross-sectional laser beam mode)

V ---------------volts

VAC-----------volts alternating current

VDC-----------volts direct current

VI --------------volt/current

W --------------watts (power)

NOTES